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RMA Turbidity and Adult Delta Smelt Behavioral Model Covering the Forecast Period February 2, 2012 to February 16, 2012

Date:	February 6, 2012
To:	Chuching Wang, Senior Engineer, Metropolitan Water District Paul Hutton, Senior Engineer, Metropolitan Water District
From:	Richard Rachiele, Principle Steve Andrews, Water Resources Engineer
Subject:	Results of Recent Forecasting Work

Summary Assessment

PERIOD: The Delta turbidity and adult delta smelt forecast was produced this week, and this documentation covers the forecast period February 2, 2012 to February 16, 2012 plus a period of historical conditions.

PRE-FORECAST SUMMARY: A weather system in late January over the Sacramento River basin brought the first high flow and turbidity conditions of the season down into the Delta. At the start of the forecast period, Sacramento flows and turbidities are still elevated, but have decreased significantly due to the lack of continuing precipitation.

TURBIDITY 3-STATIONS PERFORMANCE & SUMMARY EVALUATION: During the historical simulation period, turbidity at the Holland Cut station exceeded compliance values (12 NTU) for brief periods of time due to resuspended sediment from wind events. Turbidity is forecasted to remain below compliance values at Holland Cut and Victoria Canal. Model results indicate turbid water from the Sacramento River will affect Prisoner Point, the northernmost compliance location, increasing it above compliance values for a few days in late January and early February. However, observed CDEC data for that time period show turbidities that are just below compliance values.

SMELT MOVEMENT SUMMARY: As a result of the significant Sacramento turbidity pulse, smelt movement is anticipated up the Sacramento River and into the Northern and Central Delta.

Background

This document provides a summary of the seventh forecast for WY2012 prepared by RMA on February 2, 2012. The forecast was developed using the RMA models for hydrodynamics, salinity, and turbidity and particle tracking using the Adult Delta Smelt Behavioral model. Figures are provided to document the results of the modeling with a focus on turbidity.

Additional documentation can be found on the Bay-Delta Live website: http://www.baydeltalive.com/ .

Boundary Condition Development and Simulation Timing

Boundary conditions (BCs) for the forecast models were developed using several sources for historical and forecast conditions including: CNRFC flow data and predictions, CDEC and USGS data, DWR-supplied model inputs and results from their flow and salinity forecasts, and WARMF modeled salinity, and turbidity forecasts, provided by Systec Water Resources, Inc. BCs were prepared using these data sources and using professional judgment where necessary to resolve data discrepancies and to piece the data together for reasonable BCs.

The RMA modeled period was November 01, 2011 to February 21, 2012 for flow, salinity and turbidity, and this document presents results for the period January 01, 2011 through February 16, 2012, which include two weeks of forecast period. DWR Operations and Maintenance (O&M) group provided RMA with BCs they used in the DSM2 HYDRO and QUAL/salinity models for a combined historical and forecast period January 20, 2012 through February 21, 2012 – the three week DWR forecast period was January 31 through February 21, 2012. WARMF model results were provided for the period November 01, 2011 to February 21, 2012.

Additional flow, turbidity and EC data was downloaded for the period January 31–February 1, 2012 from the CDEC, CNRFC, and USGS websites to fill-in historical conditions in the RMA forecast models.

Historical and forecast BC for flow, turbidity and salinity were developed from sources as summarized in Table 1 through Table 3 below. Stage and export BC were compiled solely from DWR O&M sources. Flow BCs were developed using DWR flow predictions for this forecast, which were qualitatively similar to WARMF predictions. WARMF water quality forecasts were used at the Sacramento at Freeport and Cosumnes and Mokelumne River BCs. Forecasts at the other model boundaries were extended as constants, due to poor agreement of WARMF predictions with historical observed data.

Examination of the CDEC and USGS flow time series for the San Joaquin River at Vernalis showed a shift in the flow rating on December 13, 2011 of about +240 cfs. The new flow time series was used for the Vernalis flow BC for the “historical” period. The downloaded CNRFC “observed” and “forecast” flows incorporate the shift in the flow rating. A similar shift was found to occur in the Calaveras flow time series in early December and was treated similarly.

As with the previous forecast, internal turbidity boundary conditions were applied in the turbidity model (Figure 1) at both the Sacramento River at Mallard Island and Cache Slough at Ryer Island (from previous forecasts) and in the central Delta (Old River at Quimby, Mokelumne River at the San Joaquin River confluence, and the San Joaquin River at Jersey Point; as described in the Jan 19, 2012 forecast) to improve model fit during the modeled historical time period. With the exception of Mallard Island (where forecast data was extended as a constant), these internal boundary conditions were not applied during the forecast period.

WARMF Model Information

WARMF simulations in forecast mode require the best available real-time and forecast time series data to drive the simulation. There are five types of time series data used as inputs to the WARMF model: meteorology, air & rain chemistry, point sources, reservoir releases, and diversions. Data up to real-time is collected for those model inputs for which it is available—reservoir releases and many meteorology stations. All remaining time series inputs except meteorology are filled in by extrapolation using average values for each day of the year based on the historical record.

There are seven meteorology parameters used by WARMF: precipitation, minimum temperature, maximum temperature, cloud cover, dewpoint temperature, air pressure, and wind speed. The 6-day forecast meteorology is collected from the National Weather Service and entered into the WARMF database. Missing past and future meteorology data is filled in by comparing stations with missing data to nearby stations which have more complete data. Meteorology beyond the 6-day forecast window is filled in by extrapolation. All but precipitation are extrapolated by calculating the average value for each day of the year from historical data and then applying that average in the extrapolation. Extrapolated precipitation is defaulted to zero.

Forecast reservoir releases are acquired from the California Data Exchange Center and entered into the WARMF time series database. Reservoir releases beyond the scheduled period are extrapolated by continuing the last scheduled release flow through the forecast period. WARMF is first run for at least one year prior to the forecast time period to establish good initial conditions for the forecast. Then the forecast is run using the updated time series inputs.

Flow and Turbidity Model Results

Boundary inflow during most of the historical portion of the simulation was low, resulting from a lack of recent rain events. Turbidity measurements for this time span indicate suspended sediment loading from the watersheds was also very low. Depending on time and location within the Delta, measured turbidity was instead partly due to resuspension of sediments due to tidal action and/or wind events. Turbidity was low throughout the Delta, ranging from about 5–40 NTU in the raw data at nearly all locations. Turbidity data was noisy at many locations, which was particularly evident as turbidity values were so low.

These types of conditions—low boundary inflow and low watershed sediment loading with in-Delta turbidity due to sediment resuspension—are outside the current turbidity model design as turbidity is being modeled not suspended sediment. Additionally, the turbidity model calibration was optimized for high flow conditions with substantial loading from the watersheds, conditions that are hypothesized to lead to movement of delta smelt into the interior of the Delta as they follow flow and turbidity cues.

A weather system brought significant precipitation to the Sacramento watershed January 18–23, 2012. This resulted in a significant increase in flows and turbidity on the Sacramento River at Freeport (see Figures 2 and 3), the Yolo Bypass, and the Cosumnes River. These turbidity pulses caused local increases in turbidity as they made their way through the Delta, but, because of low-to-moderate export levels, stayed north of the south Delta region.

Flow and turbidity BC are illustrated in Figure 2 through Figure 11, while Figure 12 through Figure 15 illustrate export levels and Old+Middle River flows. Using information supplied by O&M for historical and forecast State (SWP) and Federal (CVP) exports, Figure 12 illustrates that daily-averaged exports decreased from a maximum of ~6,000 cfs in January to less than 5,000 cfs by early February. Figure 13 and Figure 14 are plots of Old River and Middle River flows and daily-averaged flows, respectively, while Figure 15 illustrates the combined Old+Middle River flow criterion (3-day center-weighted average) compared with CDEC data.

Figure 16 is a comparison of model output and data at the three compliance locations, and Figure 17 is a similar plot in the SWP export area. Note that Figure 17 is a comparison of data inside Clifton Court Forebay with model output at the entrance to the Forebay. For these two figures, data were cleaned (noisy values removed) and missing data filled with linear approximation. The cleaned and filled data were also daily averaged for comparison with daily-averaged model output.

Turbidity was consistently below compliance values (12 NTU) at only one of these three compliance locations. At Holland Cut, the turbidity exceeded the compliance value for several days periodically throughout December and January, in response sediment resuspended during wind events. The northernmost compliance location, at Prisoner's Point, is forecasted to exceed compliance turbidity for several days in late January–early February, in response to the pulse of turbid Sacramento River water traveling into the Central Delta. However, observed CDEC turbidity data for late January show values that remain just below the compliance value of 12 NTU.

Figure 18 and Figure 19 illustrate the progression of the main turbidity boundary conditions at Freeport and Vernalis down the Sacramento and San Joaquin Rivers, respectively. Figure 20 through Figure 26 are plots of model output compared with raw CDEC turbidity data at several in-Delta locations - these locations can be found on a map of the Delta in Figure 27. The turbidity model captured the transport of the turbidity pulse through the north and central Delta, and the generally low turbidity in the south.

Adult Delta Smelt Particle Tracking Model Results

Figure 28 through Figure 31 present the turbidity contour plots and particle tracking model results for the runs using the data-derived turbidity and EC boundary conditions listed in Table 2 and Table 3—RMA-modeled turbidity is in left plot and particle tracking model results are in the right plot. The Delta Smelt behavioral model was run November 01, 2011 to February 21, 2012; 50,000 particles were inserted on November 01. These plots illustrate that just prior to the forecast period, turbidity was increased throughout the north and central Delta. This turbidity quickly decreased due to lower turbidity inflows from the Sacramento by the end of the 2-week forecast period (Figure 31). None of the modeled particles reached the export locations during the simulation; however a small number of delta smelt were reported by DFG as being salvaged at the CVP pump locations on January 18, 24–31 (Figure 32).

MWD Training

Model input files and results were provided to Chuching Wang for remote access on the RMA intranet.

List of Acronyms:
WY ~ Water Year
SWP ~ State Water Project
CVP ~ Central Valley Project
CCFB ~ Clifton Court Forebay
CNRFC ~ California-Nevada River Forecasting Center
CDEC ~ California Data Exchange Center
CIMIS ~ California Irrigation Management System
DWR ~ California Department of Water Resources
USGS ~ United States Geological Survey
RMA ~ Resource Management Associates
WARMF ~ Watershed Analysis Risk Management Framework
DFG ~ California Department of Fish and Game

CDEC Stations:
FPT ~ Freeport
MAL~ Sacramento River at Mallard Island
RYI ~ Cache Sl. at Ryer Island
SMR ~ South Fork Mokelumne River
MRZ ~ Martinez
VNS ~ Vernalis

DSM2 Boundary Locations:
RMKL070 ~ Mokelumne River
RCSM075 ~ Cosumnes River
RCAL009 ~ Calaveras River
RSAN112 ~ San Joaquin River
BYOLO040 ~ Yolo Bypass
RSAC054 ~ Martinez

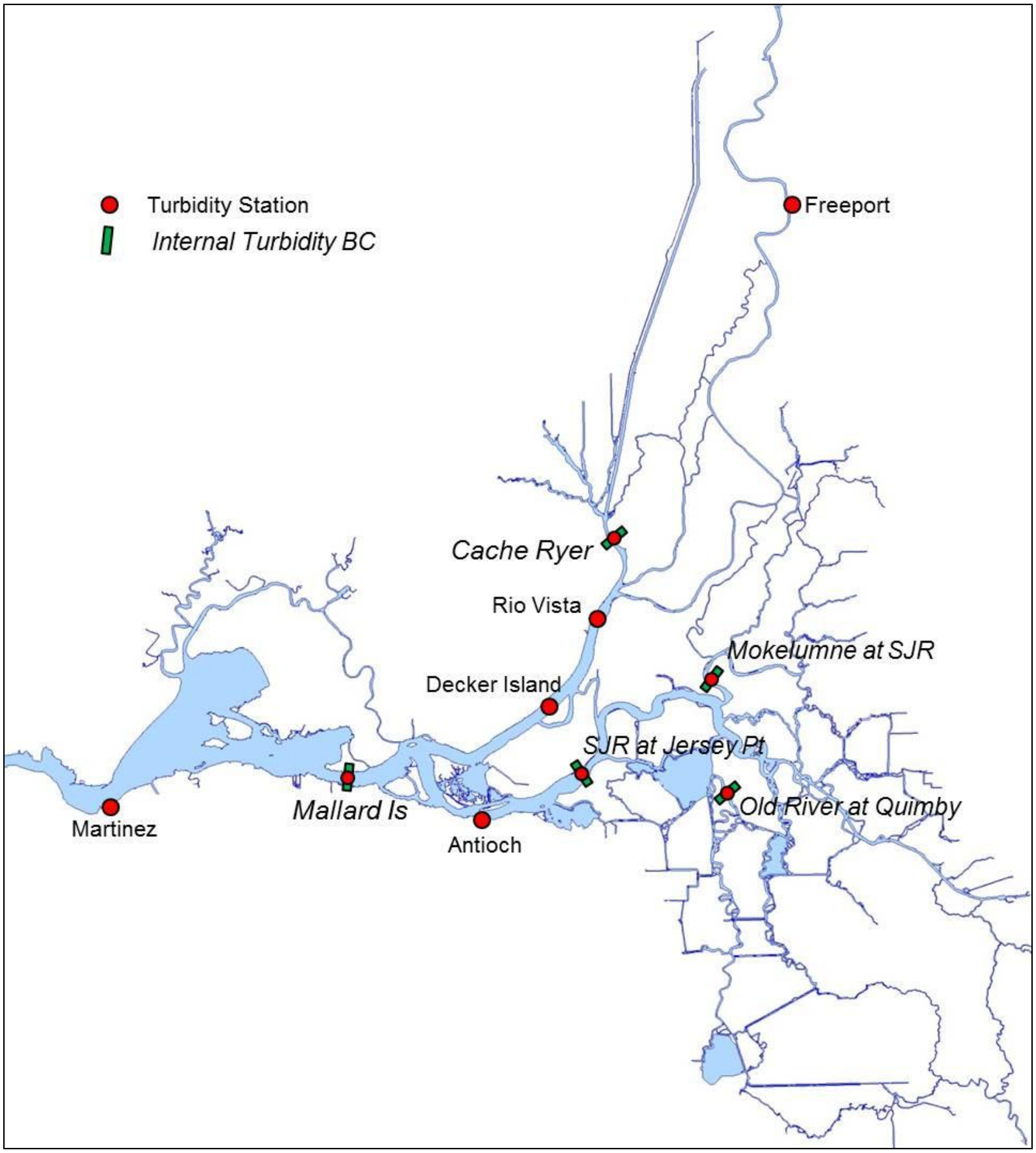

Figure 1 Locations of the internal turbidity boundary conditions used in the current turbidity forecast model run. Boundary conditions at the Mokelumne River at SJR, the SJR at Jersey Point, and Old River at Quimby Island were implemented in the January 19, 2012 forecast.

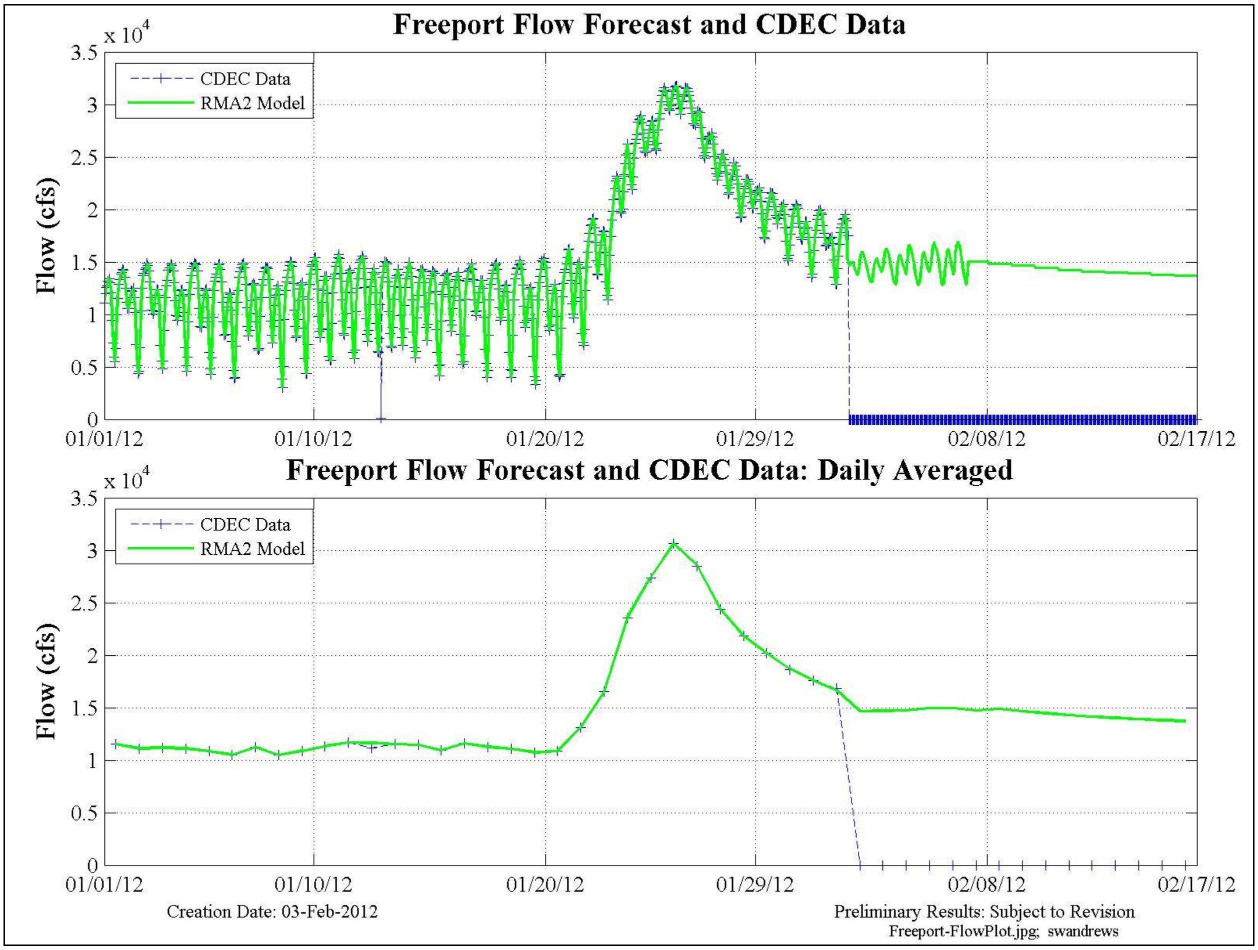

Figure 2 Freeport flow BC was compiled using CDEC data, CNRFC forecast, and then DWR DSM2 forecast. Note y-axis unit is cfs*10,000. Zero values indicate the end of data (blue).

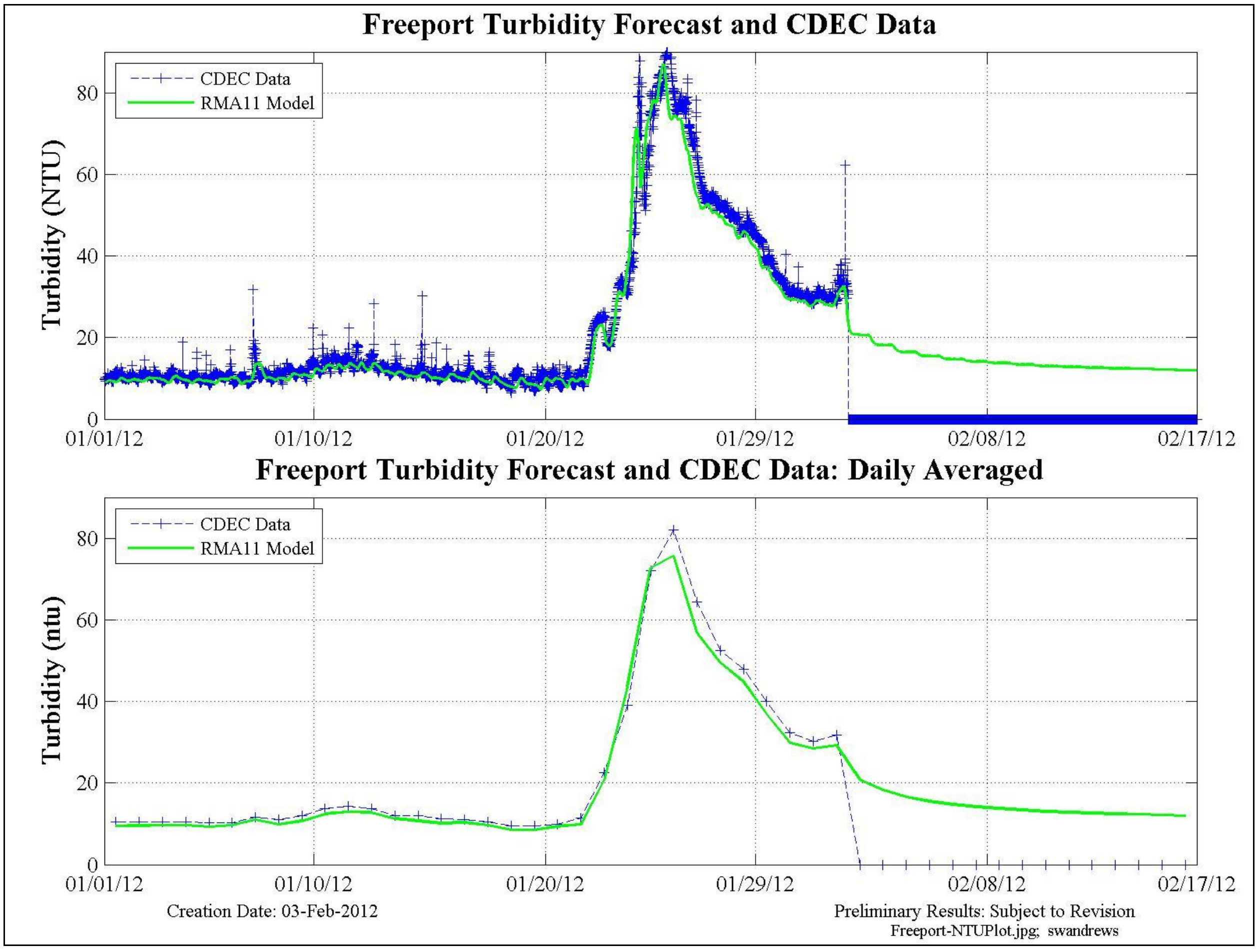

Figure 3 Freeport turbidity BC was compiled using CDEC data followed by the WARMF forecast. Zero values indicate the end of data (blue).

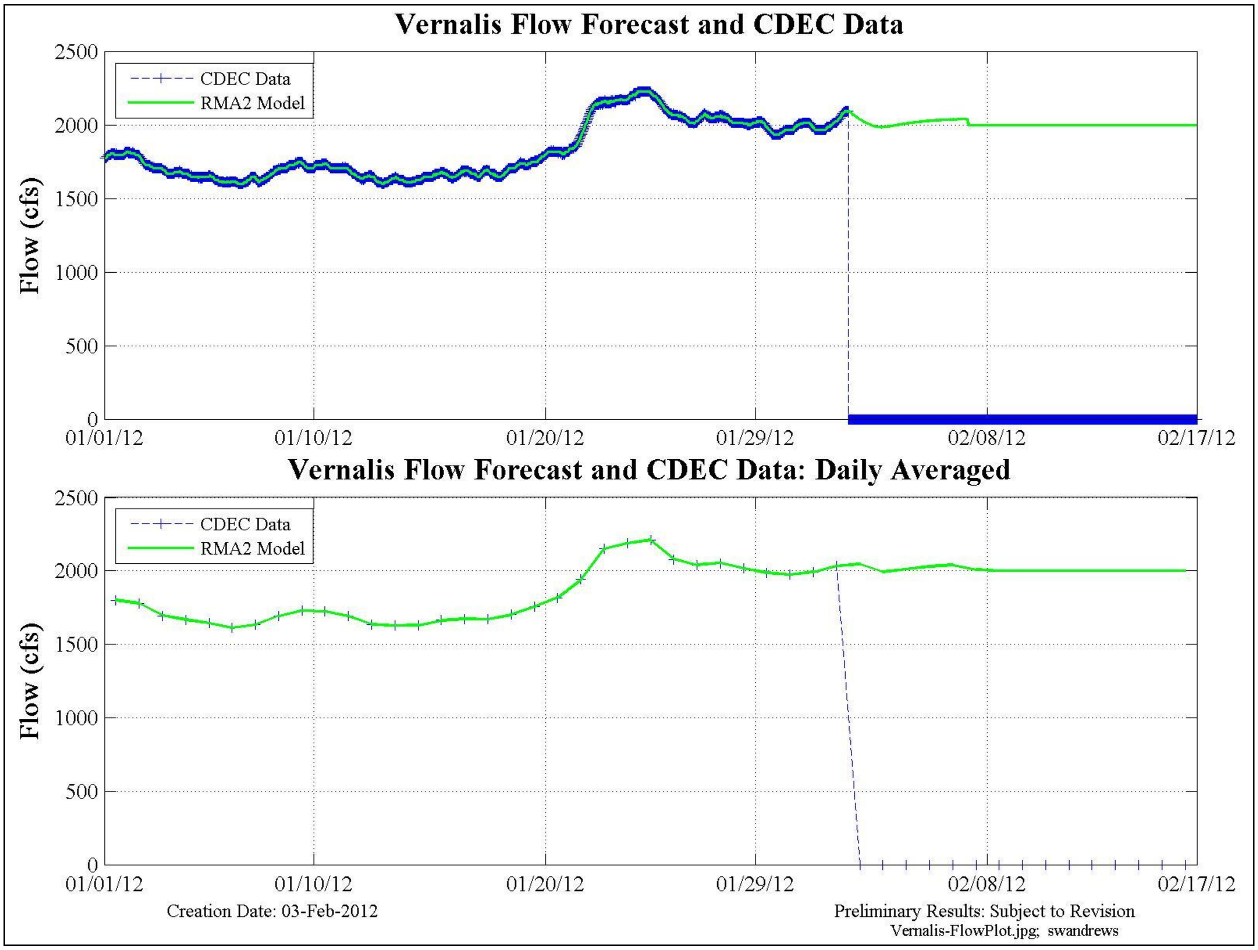

Figure 4 Vernalis flow BC was compiled using CDEC and USGS data and DWR DSM2 forecast flow. Zero values indicate the end of data (blue).

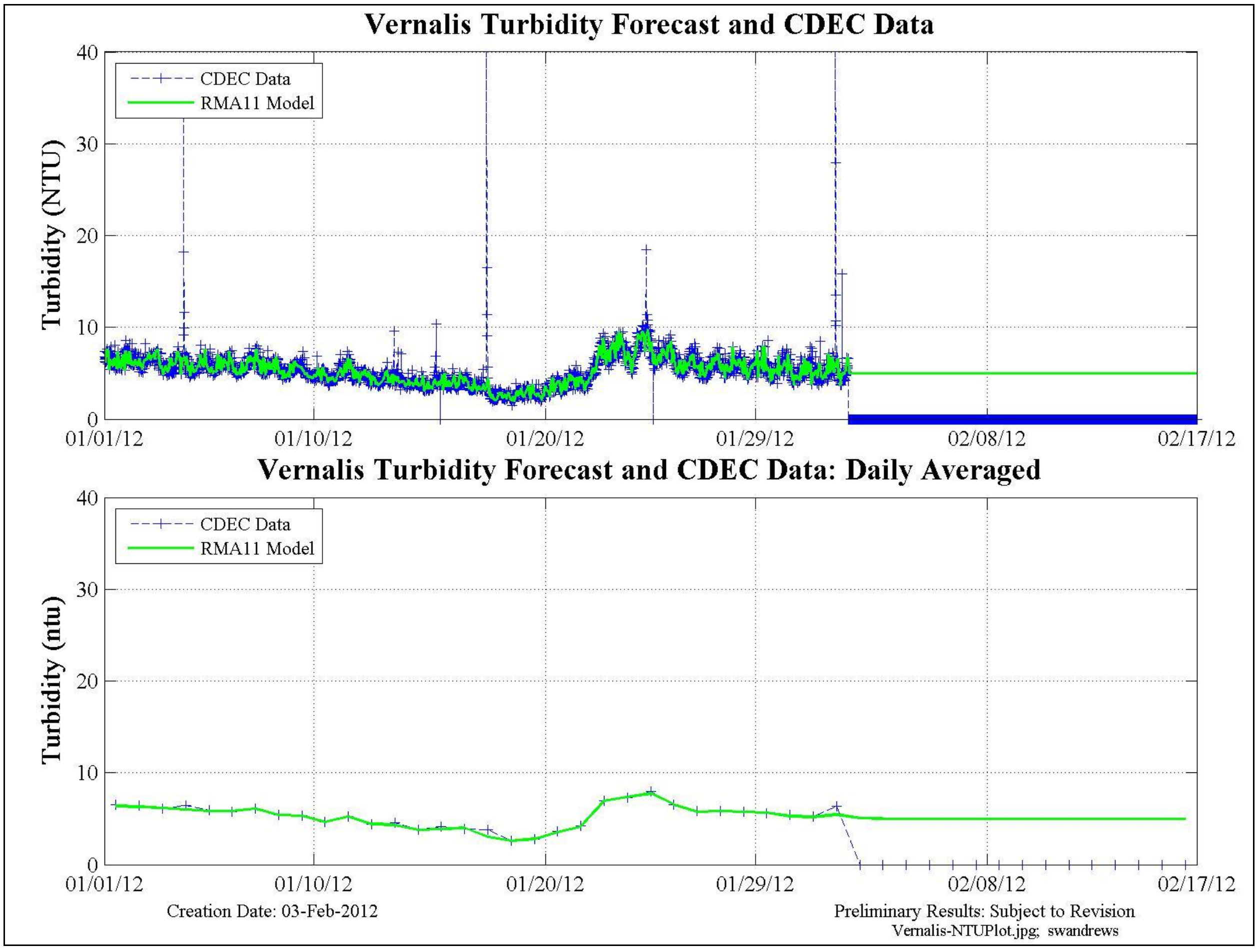

Figure 5 Vernalis turbidity BC was compiled using CDEC data, then extended as a constant. Zero values indicate the end of data (blue).

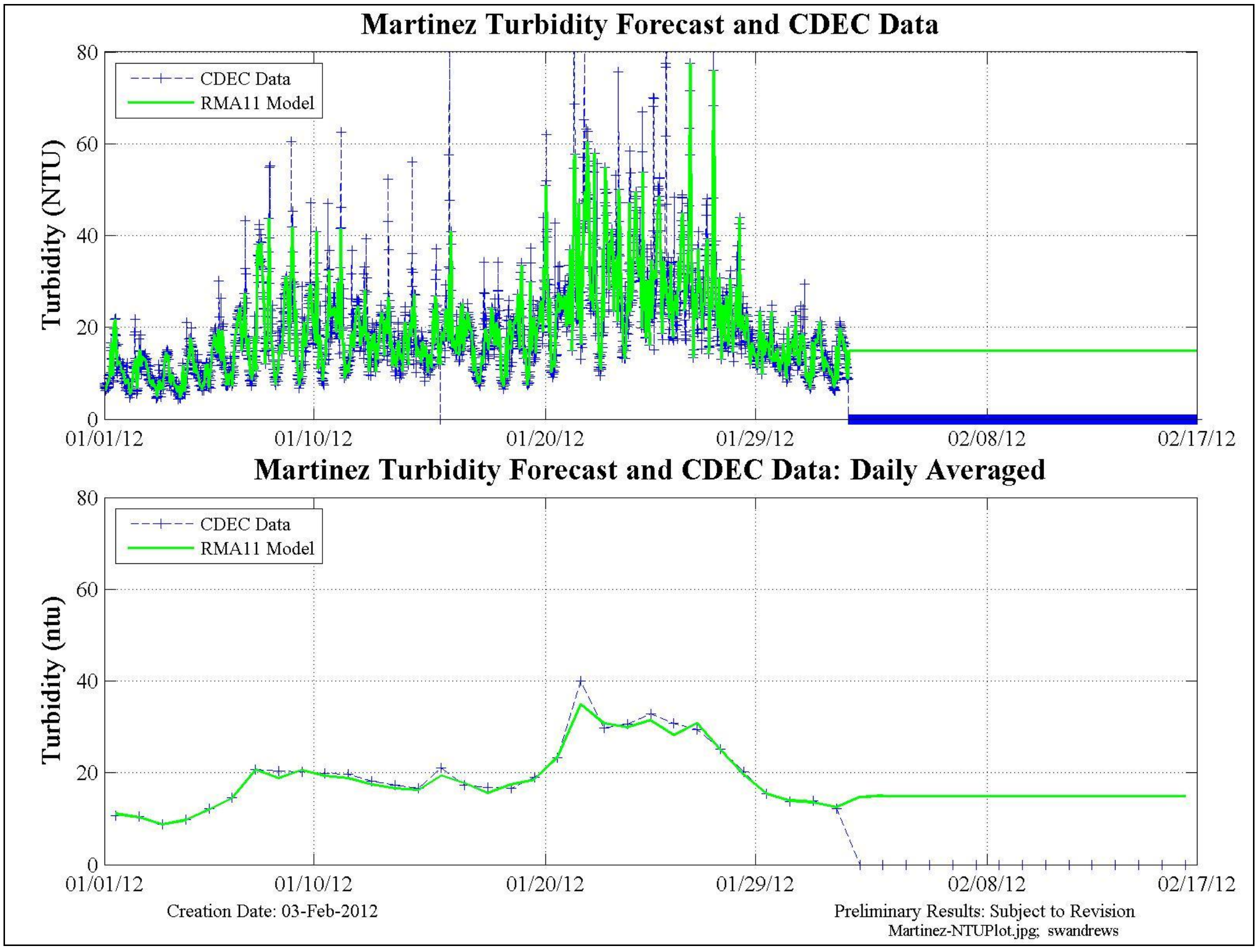

Figure 6 Martinez turbidity BC was compiled from CDEC data then extended linearly to a value of 15 NTU. Zero values indicate the end of data (blue).

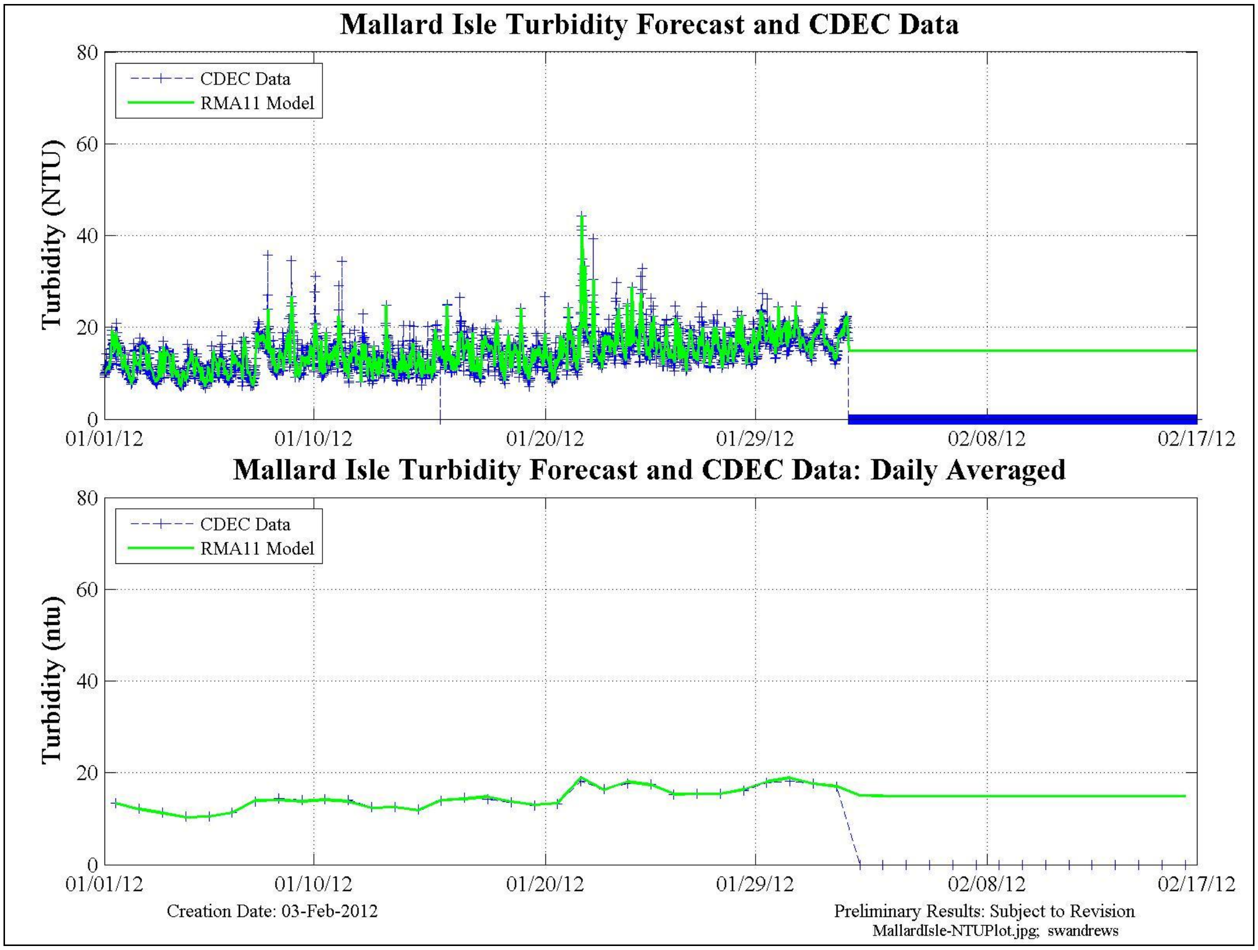

Figure 7 The Sacramento River at Mallard Island internal turbidity BC was compiled from CDEC data then extended linearly to a value of 15 NTU. Zero values indicate the end of data (blue).

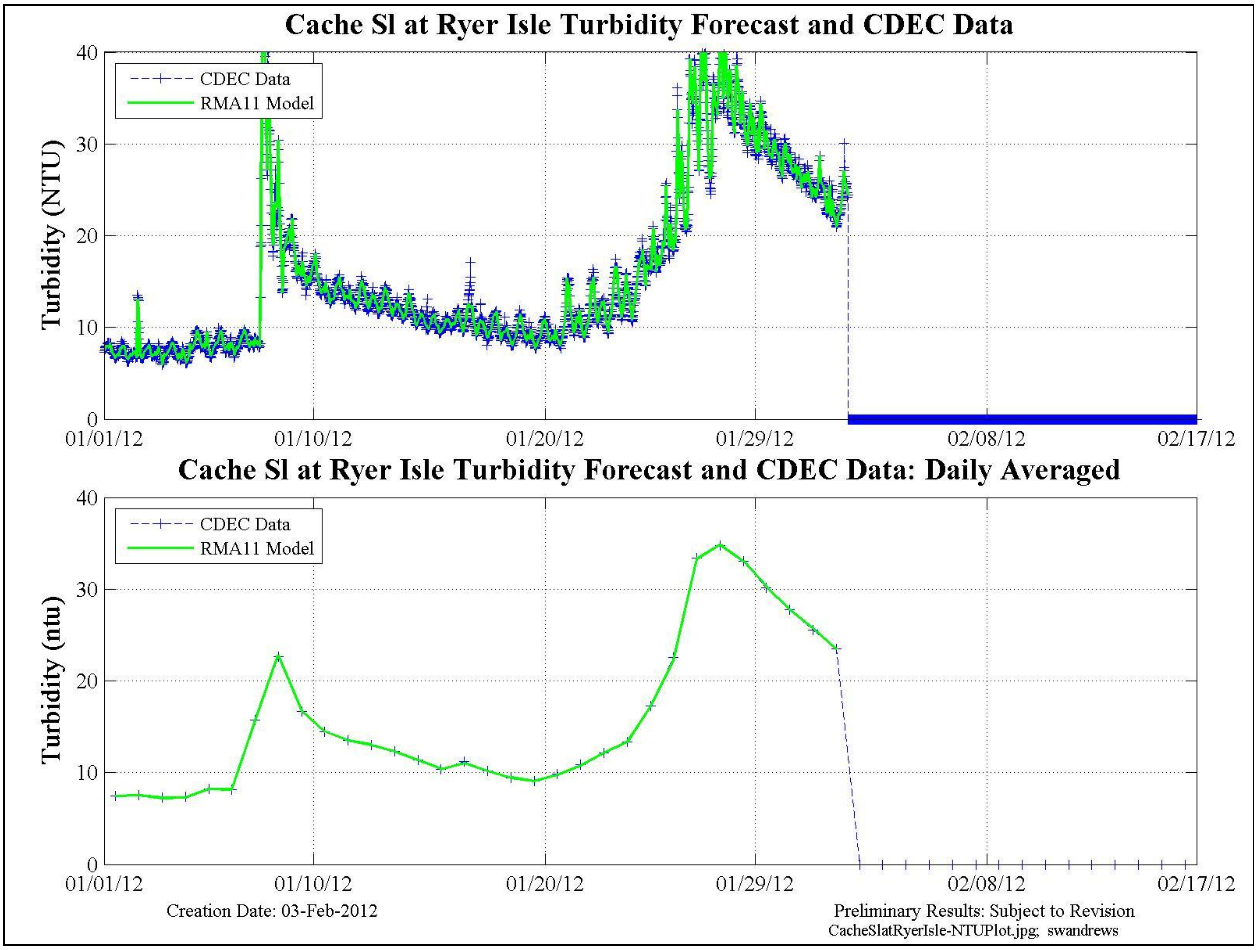

Figure 8 The Cache Slough at Ryer Island internal turbidity BC was compiled from CDEC data. The boundary condition was not applied beyond the end time of the observed data. Zero values indicate the end of data application period (blue).

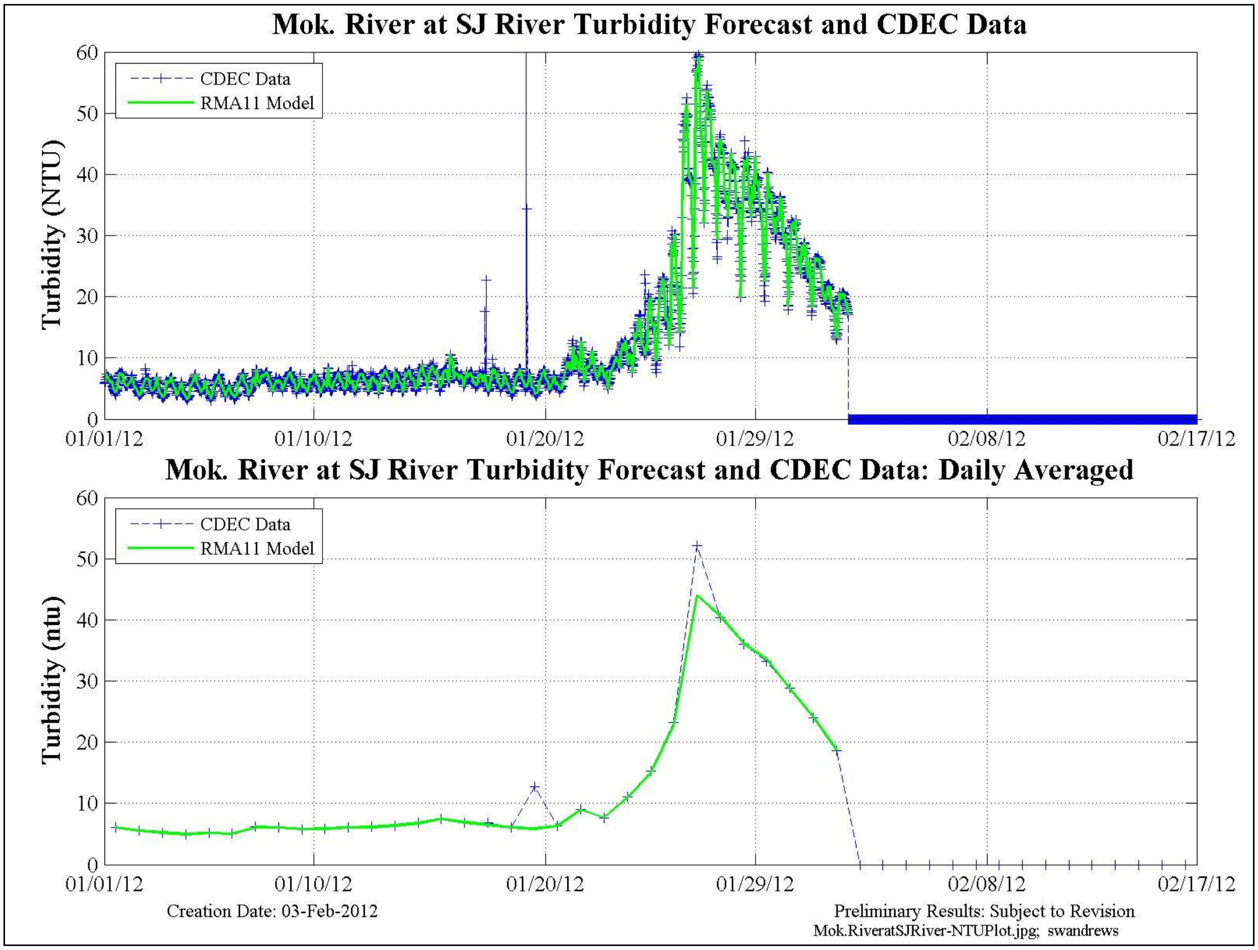

Figure 9 The Mokelumne River at the San Joaquin River confluence internal turbidity BC was compiled from CDEC data. The boundary condition was not applied beyond the end time of the observed data. Zero values indicate the end of data application period (blue).

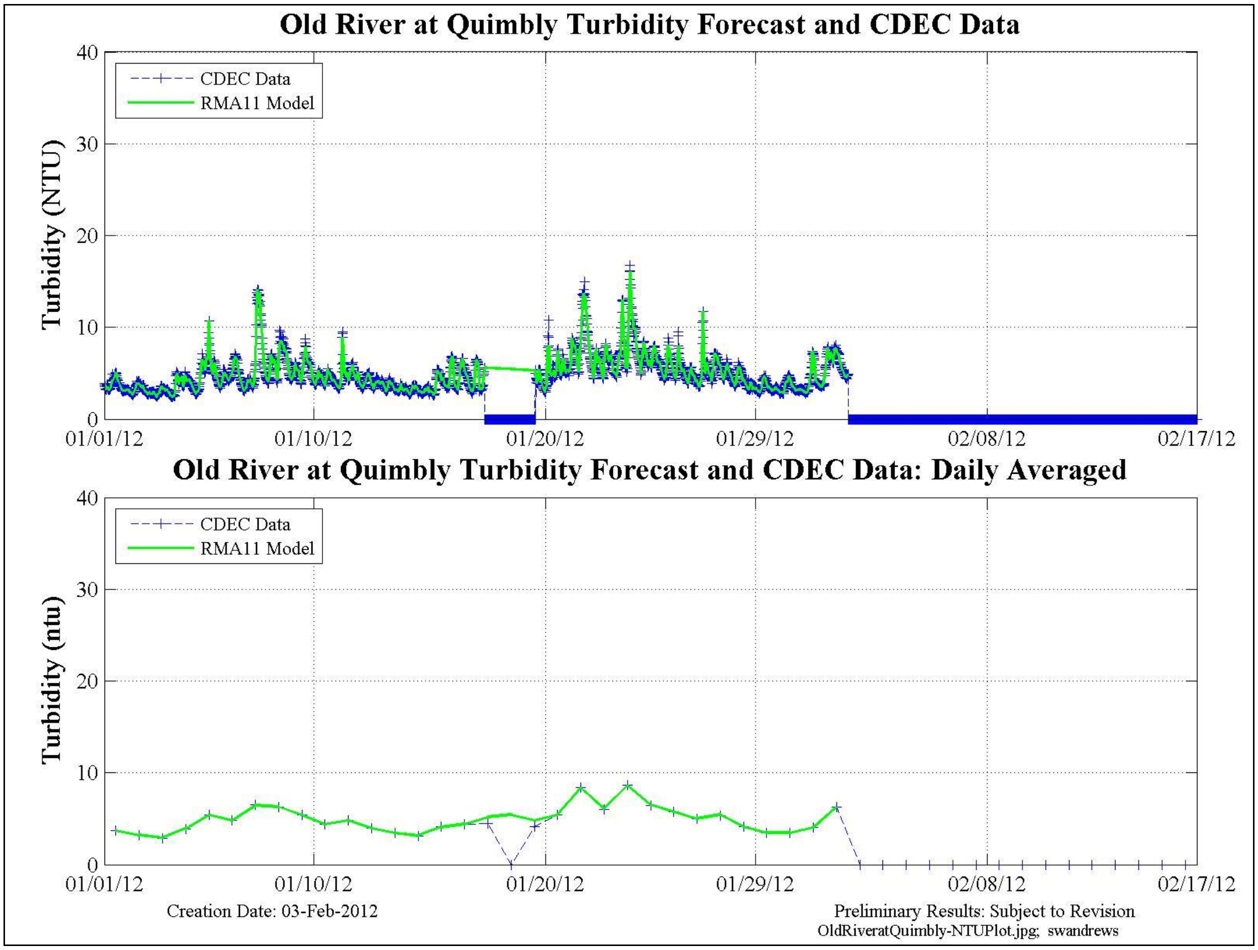

Figure 10 The Old River at Quimby Island internal turbidity BC was compiled from CDEC data. The boundary condition was not applied beyond the end time of the observed data. Zero values indicate the end of data application period (blue).

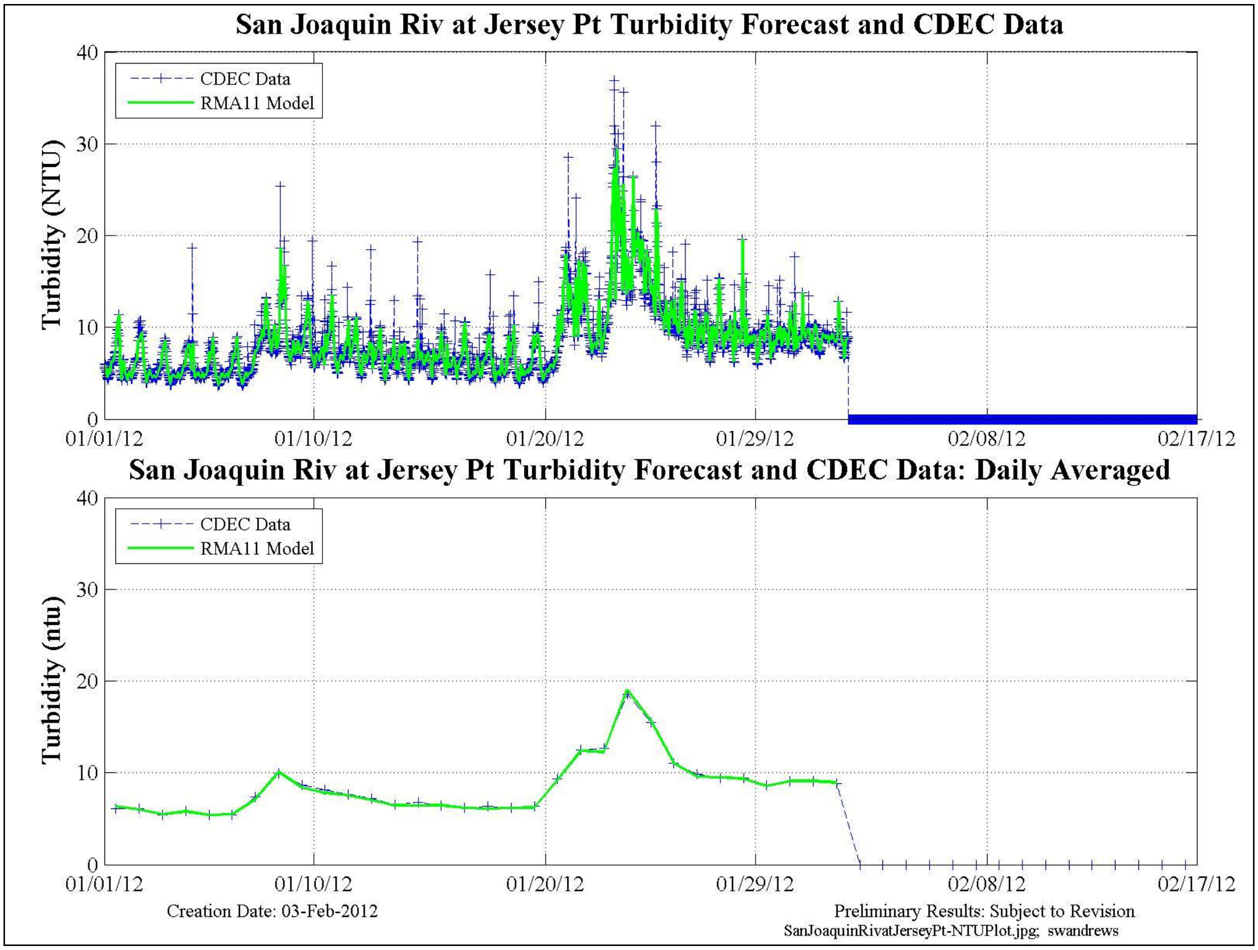

Figure 11 The San Joaquin River at Jersey Point internal turbidity BC was compiled from CDEC data. The boundary condition was not applied beyond the end time of the observed data. Zero values indicate the end of data application period (blue).

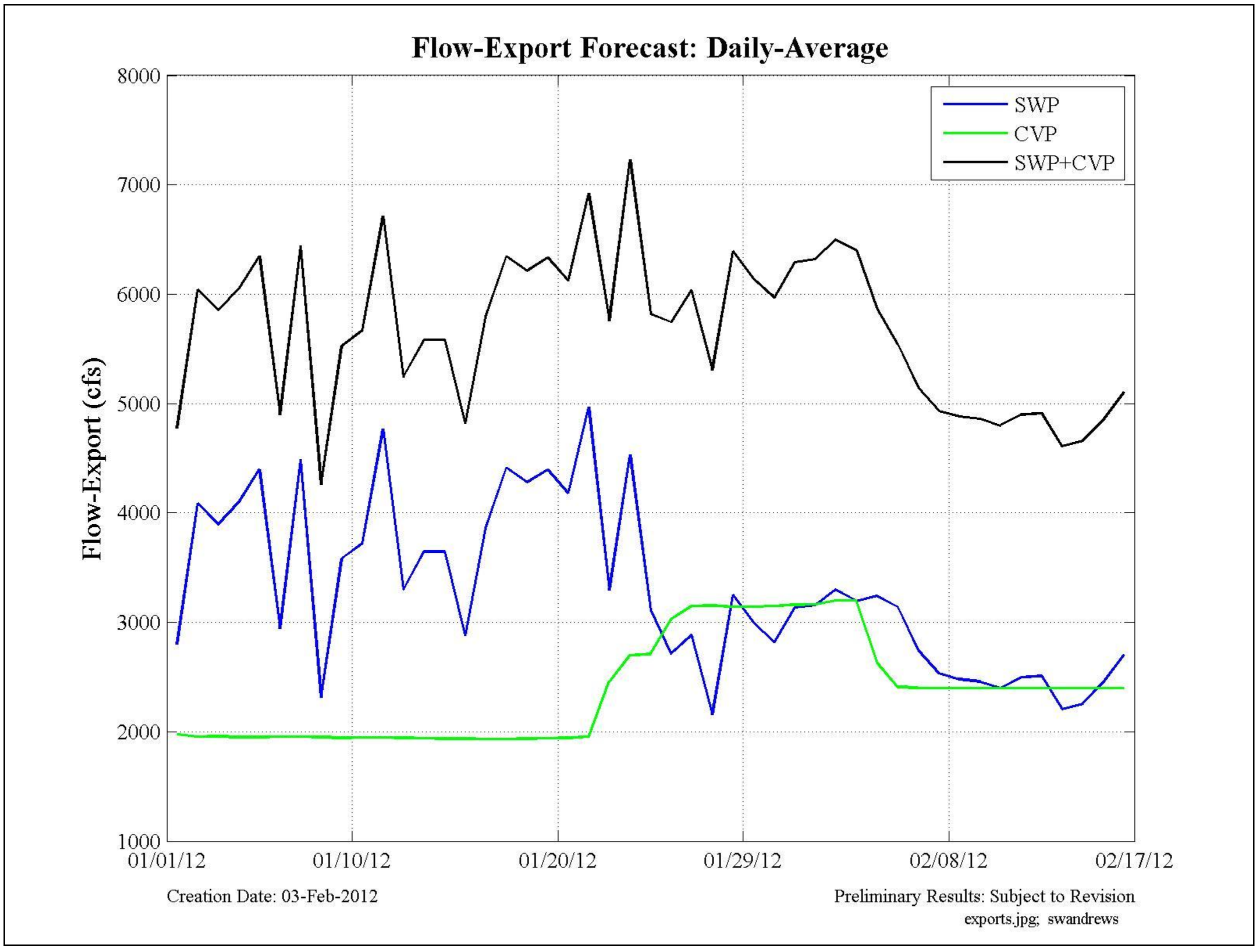

Figure 12 Historical and modeled daily-averaged exports at the SWP and CVP export locations, and the combined SWP+CVP exports.

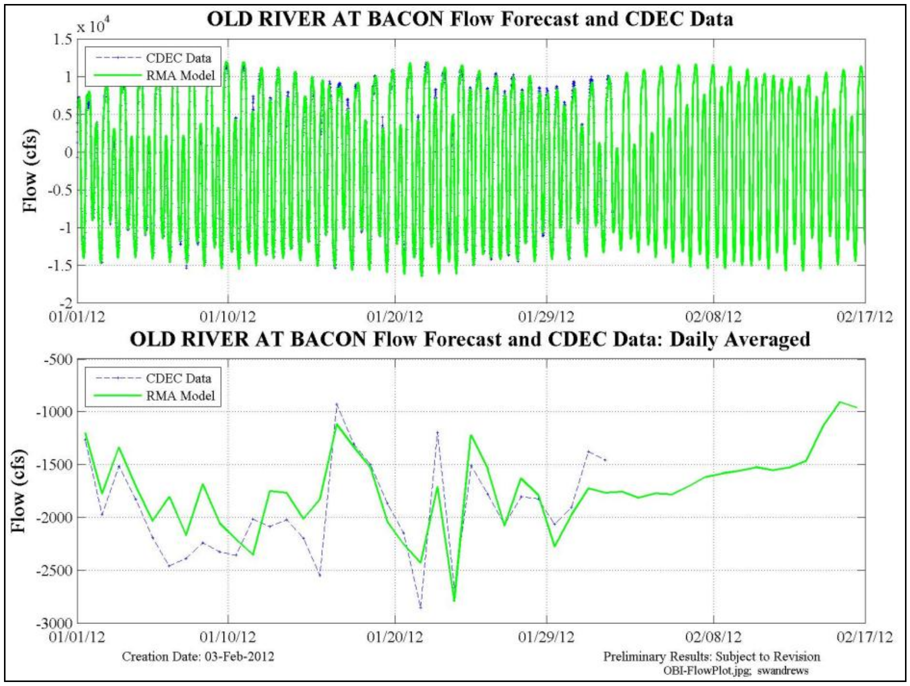

Figure 13 Model flow forecast output and raw CDEC data at Old River at Bacon (ROLD024) location. Both 15-min (upper) and daily averaged (lower) plots are shown.

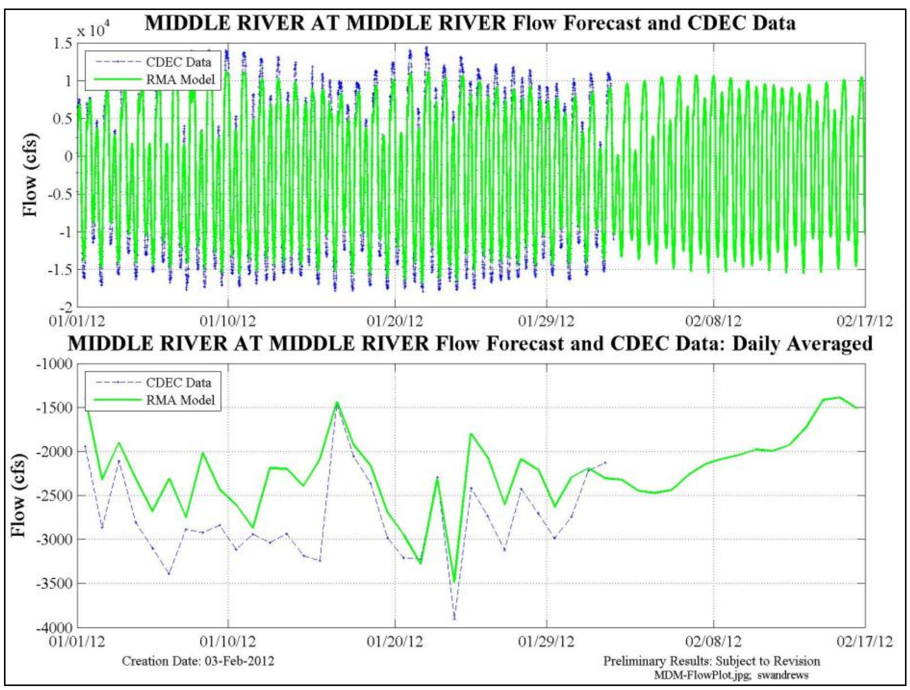

Figure 14 Model flow forecast output and raw CDEC data the Middle River-at-Middle (RMID015) location. Both 15-min (upper) and daily averaged (lower) plots are shown.

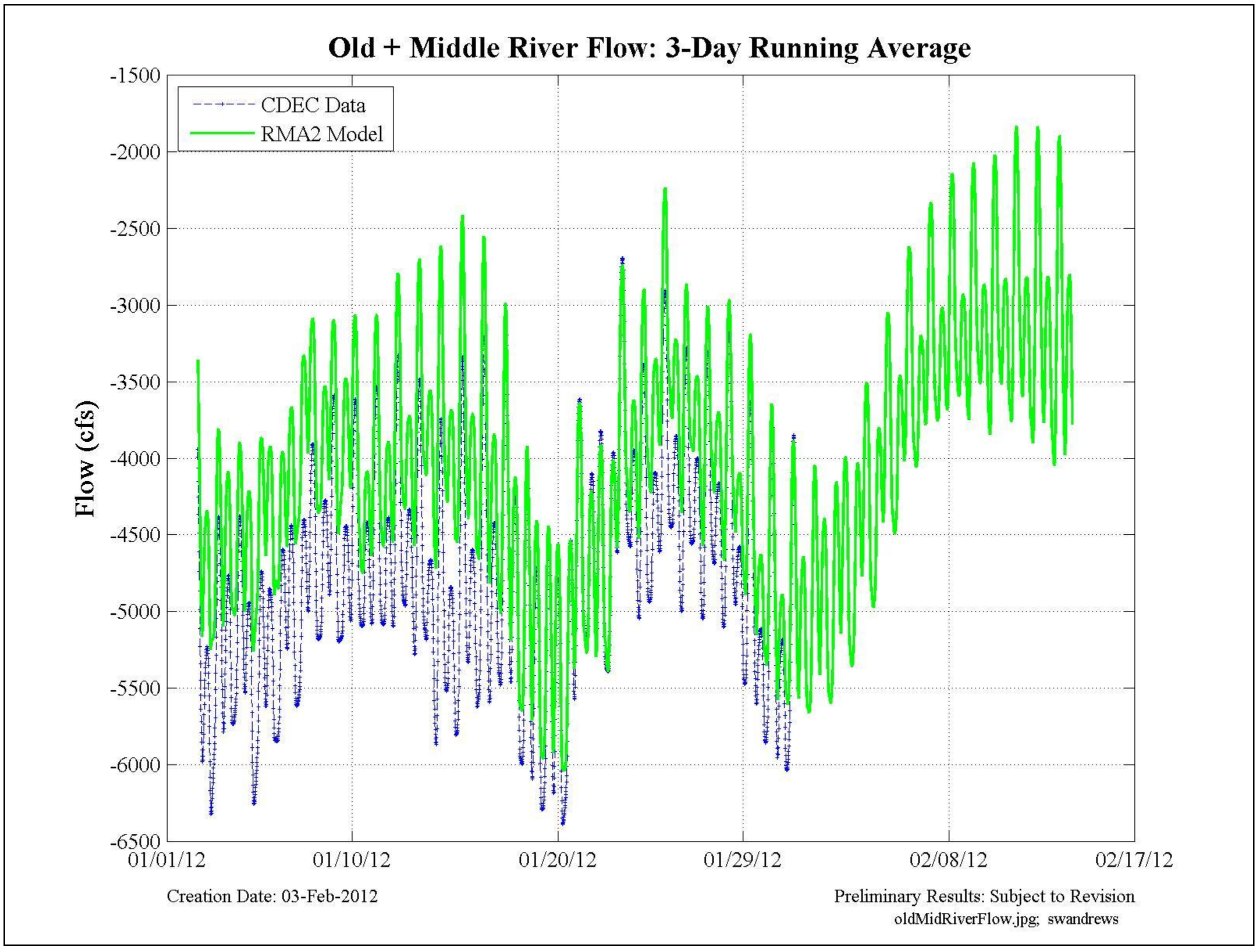

Figure 15 Model flow forecast output and raw CDEC data for the Old+Middle River flow criterion for three-day running-average flow.

Table 1 Boundary condition development for flow for this forecast period.

February 2, 2012	Historical DWR BC	Definition Historical Flow	Definition Forecast Flow	Comment
BC Location				
Yolo Bypass	Not used	Hourly CDEC LIS, cleaned+filled	Hourly CNRFC forecast (Yolo at Lisbon) for 5 days, constant 400cfs flow after	DWR flow prediction too low
Sacramento River at Freeport	Not used	Hourly CDEC FPT, cleaned+filled	Hourly CNRFC forecast (Sac R at I St.) for 5 days, Daily DSM2 RSAC155 results after, converted to hourly	
Mokelumne River	Daily DSM2 RMKL070, converted to hourly	Not used	Daily DSM2 RMKL070 results, converted to hourly	
Cosumnes River	Not used	Hourly CNRFC Cosumnes-McConnell, cleaned+filled	Hourly CNRFC forecast (Cosumnes R at McConnell) for 5 days, Daily DSM2 RCSM075 results after, converted to hourly	
Calaveras River	Not used	Hourly CDEC MRS, cleaned+filled	Daily DSM2 RCAL009 results, converted to hourly	Shifted CDEC data 28Nov-12Dec +37cfs to account for jump in data record
San Joaquin River at Vernalis	Not used	Hourly CDEC VNS, cleaned+filled	Hourly CNRFC forecast (SJ R at Vernalis) for 5 days, Daily DSM2 RSAN112 results after, converted to hourly	CDEC data shifted 240 cfs prior to Dec 13 to match USGS site data
Stage - Martinez	Not used	15min CDEC Martinez stage, cleaned+filled, and shifted -2.38 ft.	15min astronomically based DSM2 RSAC054	

Table 2 Boundary condition development for turbidity for this forecast period.

February 2, 2012	Definition Historical NTU	Definition Forecast NTU	Comment
BC Location			
Yolo Bypass	15min CDEC RYI, cleaned+filled, hourly averaged	linearly interpolated from last observed NTU to 10 NTU, then extended as constant	WARMF prediction too high
Cache Slough at Ryer internal BC	15min CDEC RYI, cleaned+filled, hourly averaged	not applied	
Sacramento River at Freeport	15min CDEC FPT, cleaned+filled, hourly averaged then shifted -15hrs to account for travel time from upstream boundary	WARMF	Constant value of 9.5NTU used between Dec. 1 and Dec. 27 because of FPT sensor problem
Mokelumne River	15min CDEC SMR, cleaned+filled, daily averaged then converted to hourly	WARMF	
Cosumnes River	15min CDEC SMR, cleaned+filled, daily averaged then converted to hourly	WARMF	
Calaveras River	15min CDEC RRI, cleaned+filled, hourly averaged	extended as constant	
San Joaquin River at Vernalis	15min CDEC SJR, cleaned+filled, hourly averaged	extended as constant	
Mokelumne River at San Joaquin confluence internal BC	15min CDEC MOK, cleaned+filled, hourly averaged	not applied	
Old River at Quimbly Island internal BC	15min CDEC ORQ, cleaned+filled, hourly averaged	not applied	
San Joaquin at Jersey Pt internal BC	15min CDEC SJJ, cleaned+filled, hourly averaged	not applied	Not applied prior to Nov. 28 because of SJJ sensor problem
Sacramento River at Mallard Island internal BC	15min CDEC MAL, cleaned+filled, hourly averaged	extended as constant	
Martinez	15min CDEC MRZ, cleaned+filled, hourly averaged	extended as constant	

Table 3 Boundary condition development for EC for this forecast period.

February 2, 2012	Historical DWR BC	Definition Historical EC	Definition Forecast EC	Comment
BC Location				
Yolo Bypass	Not used	15min CDEC RYI, cleaned+filled, hourly averaged	extend as constant	
Sacramento River at Freeport	Not used	15min CDEC FPT, cleaned+filled, hourly averaged	WARMF	Shift back 15 hrs
Mokelumne River	Not used	15min CDEC SMR, cleaned+filled, filtered to remove tidal spikes in EC from the Sac River, daily averaged then converted to hourly	WARMF	Daily-avg to remove tidal variation, filter when when DCC open
Cosumnes River	Not used	15min CDEC SMR, cleaned+filled, filtered to remove tidal spikes in EC from the Sac River, daily averaged then converted to hourly	extend as constant	Daily-avg to remove tidal variation, filter when when DCC open
Calaveras River	Not used	15min CDEC RRI, cleaned+filled, hourly averaged	extend as constant	tidal variation not removed
San Joaquin River at Vernalis	Not used	15min CDEC SJR, cleaned+filled, hourly averaged	extend as constant	
Martinez	Not used	15min CDEC MRZ, cleaned+filled, hourly averaged	DWR forecast (quality.dss)	

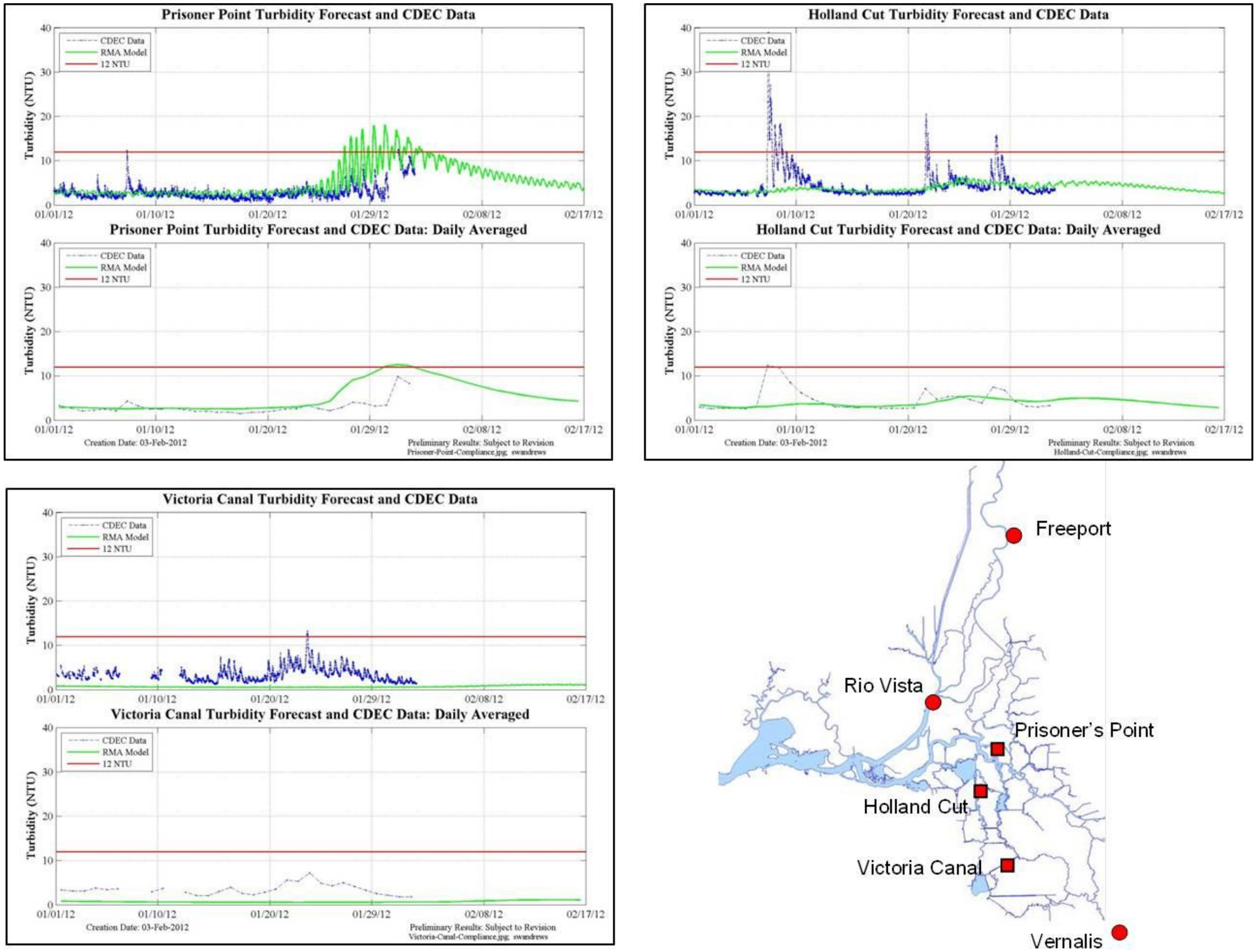

Figure 16 Modeled turbidity and data (cleaned and filled) at the three compliance locations. Both 15-min model output and data and daily averaged plots are shown. Red line illustrates the 12-NTU compliance value.

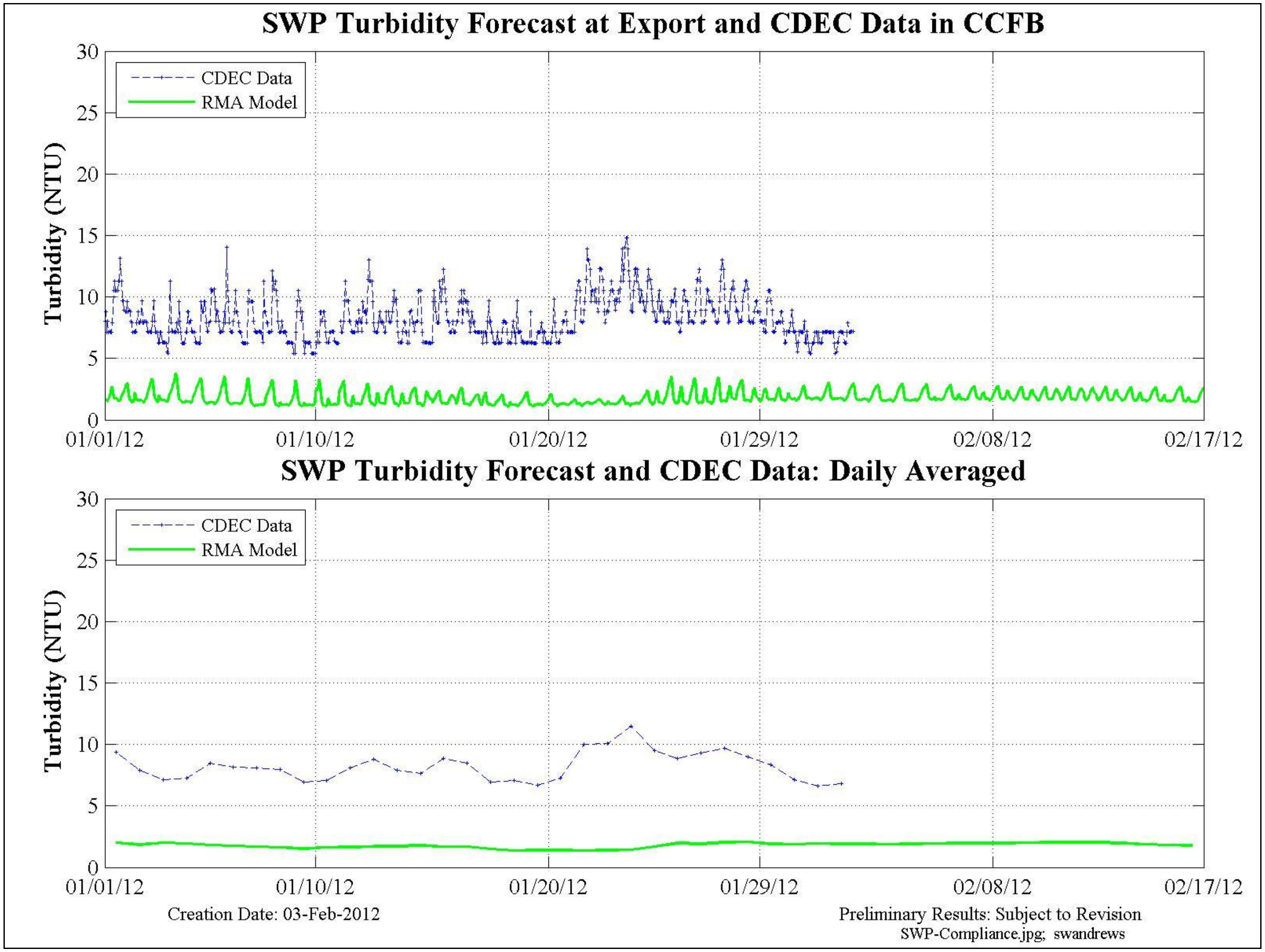

Figure 17 Plots compare model output at the SWP export location with data gathered inside Clifton Court Forebay. Both 15-min model output and daily averaged plots are shown.

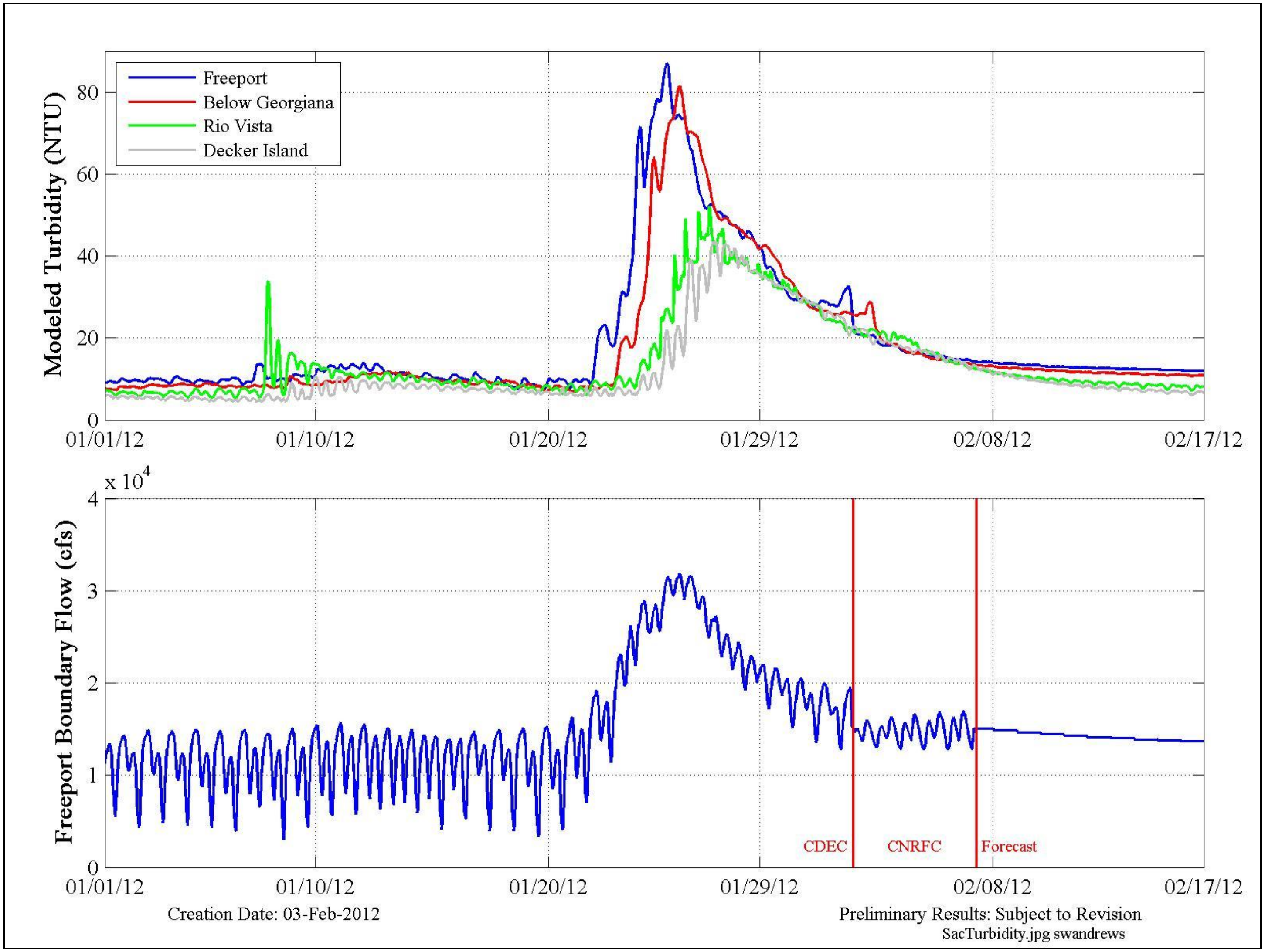

Figure 18 Freeport turbidity boundary condition progression down the Sacramento R. (upper plot) along with the flow boundary (lower plot) used during the historical and forecast periods. Forecast began on February 2, 2012.

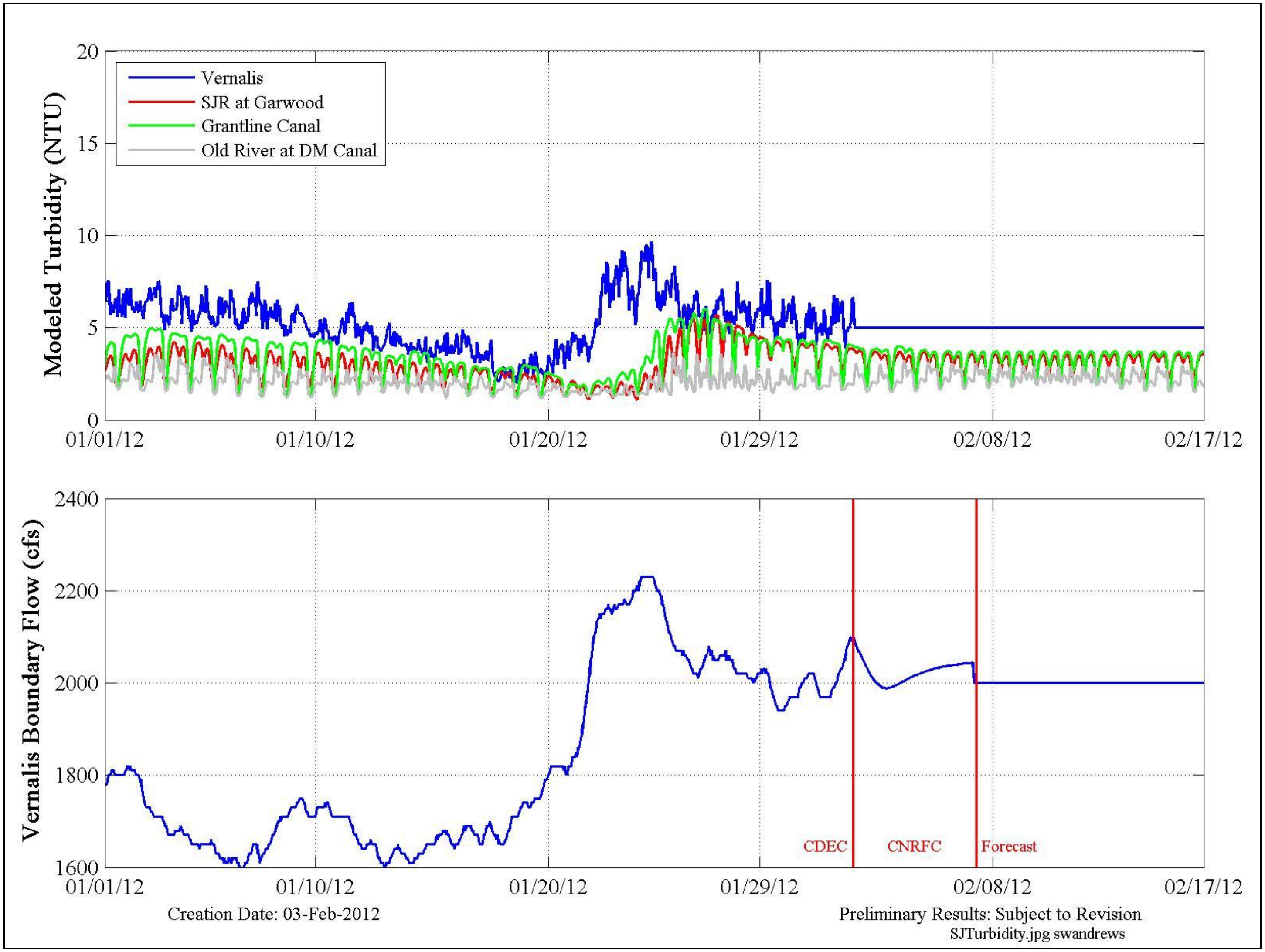

Figure 19 Progression of the turbidity boundary condition from Vernalis down the San Joaquin R. to Garwood, and down Old River. Vernalis flow forecast periods indicated by red lines (upper plot). Flow boundary conditions at Vernalis are shown in the lower plot.

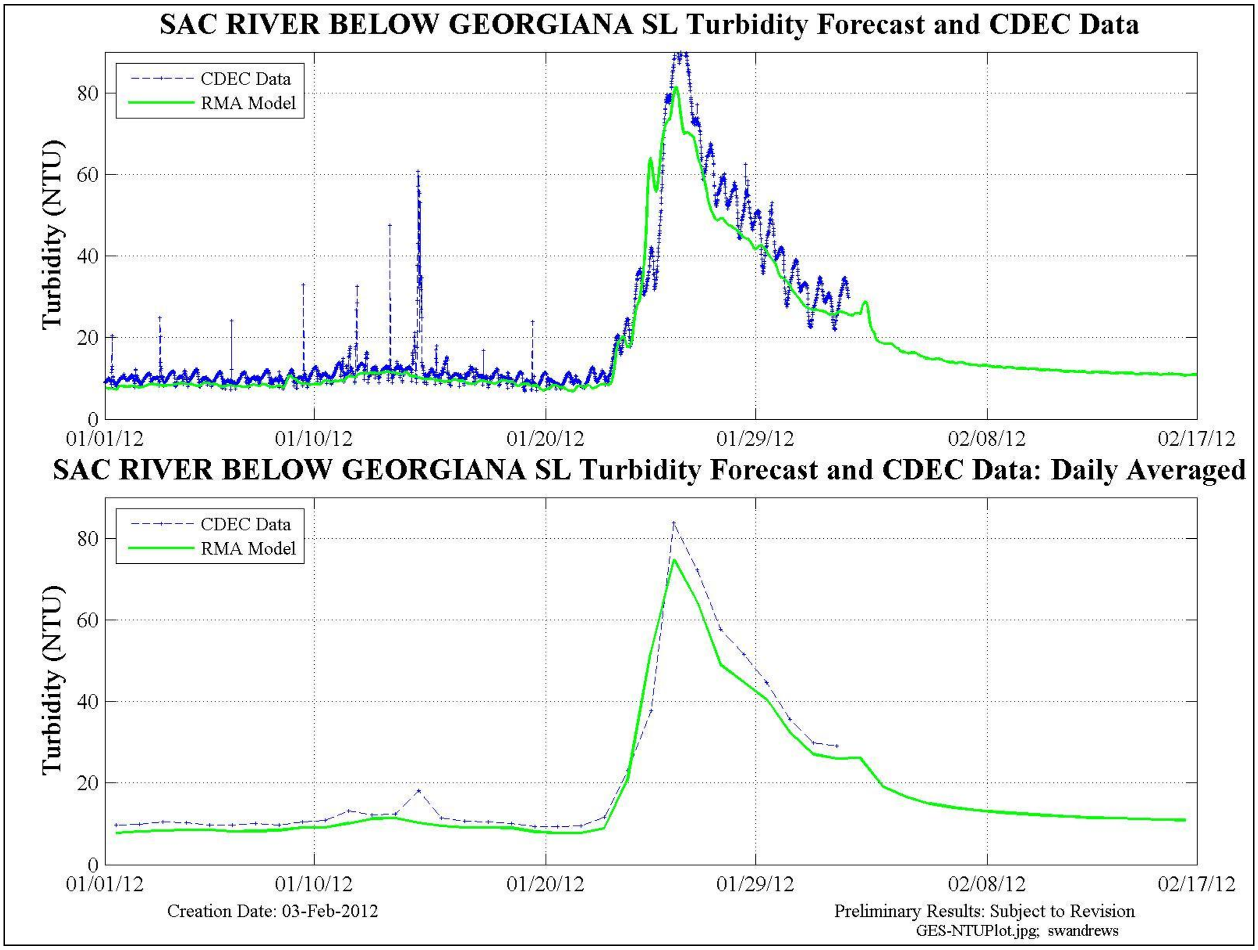

Figure 20 Model forecast and raw CDEC data at Sac. River Below Georgiana Sl. Both 15-min (upper) and daily averaged (lower) plots are shown.

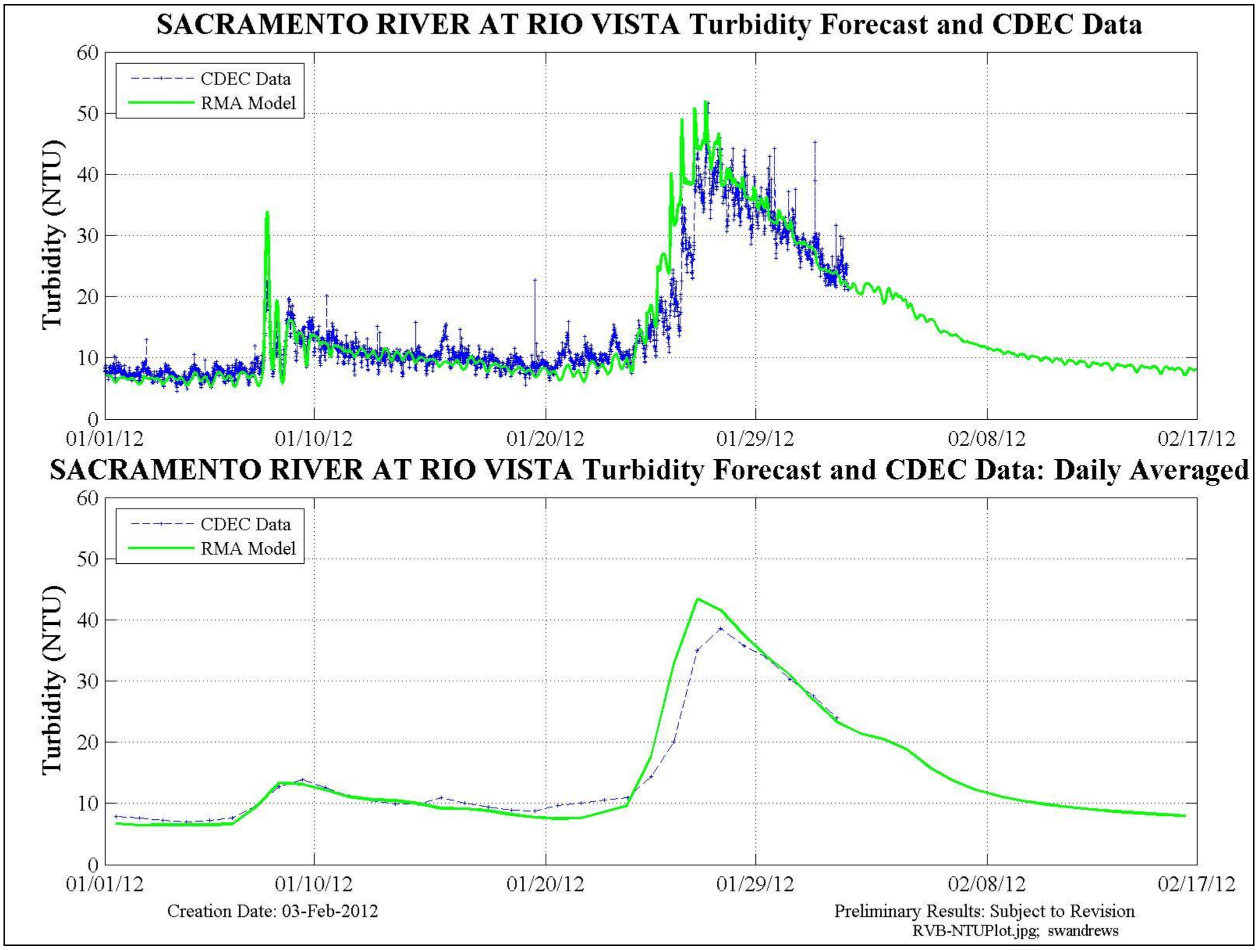

Figure 21 Model forecast and raw CDEC data at Rio Vista. Both 15-min (upper) and daily averaged (lower) plots are shown.

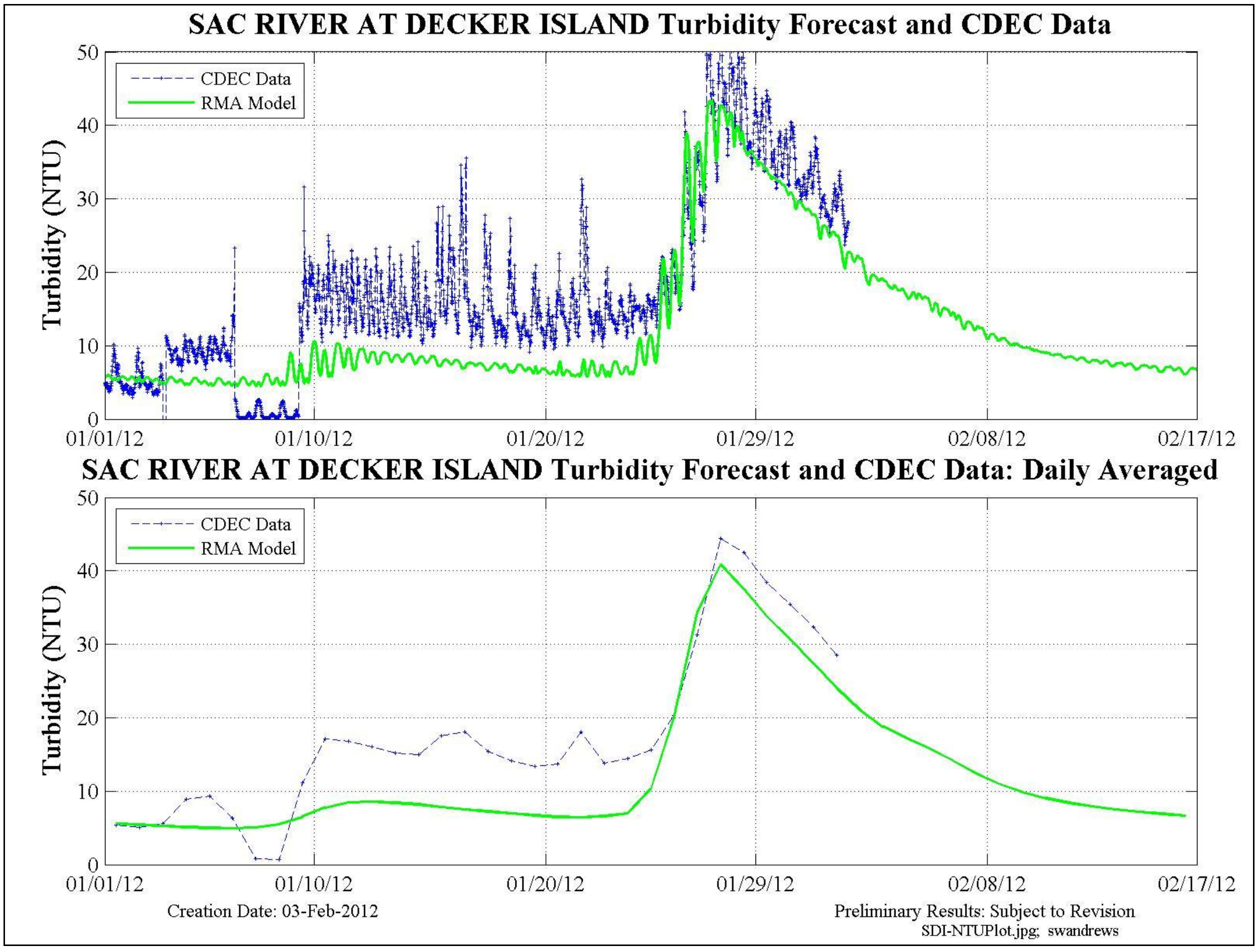

Figure 22 Model forecast and raw CDEC data at Decker Island. Both 15-min (upper) and daily averaged (lower) plots are shown.

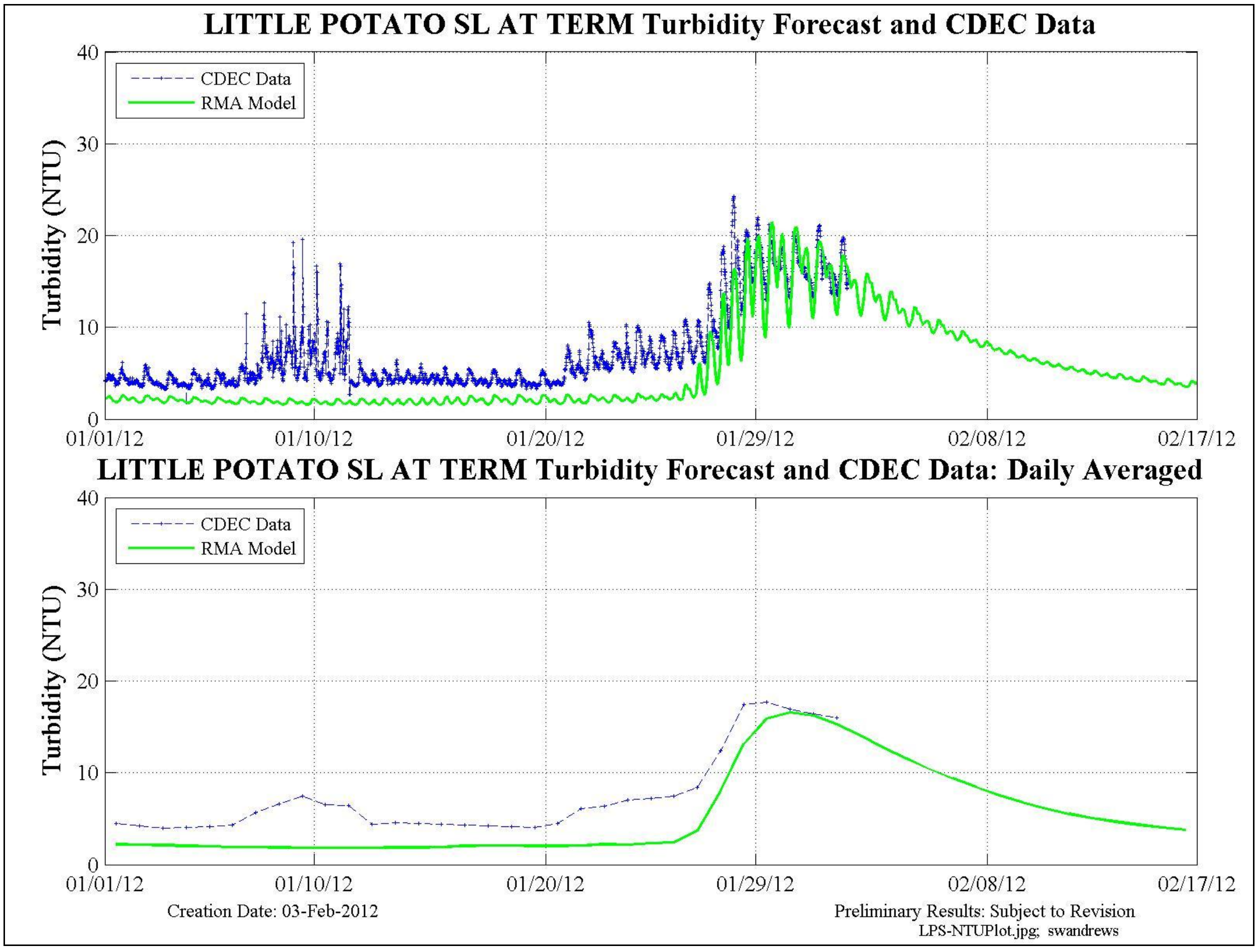

Figure 23 Model forecast and raw CDEC data at Little Potato Slough at Terminous. Both 15-min (upper) and daily averaged (lower) plots are shown.

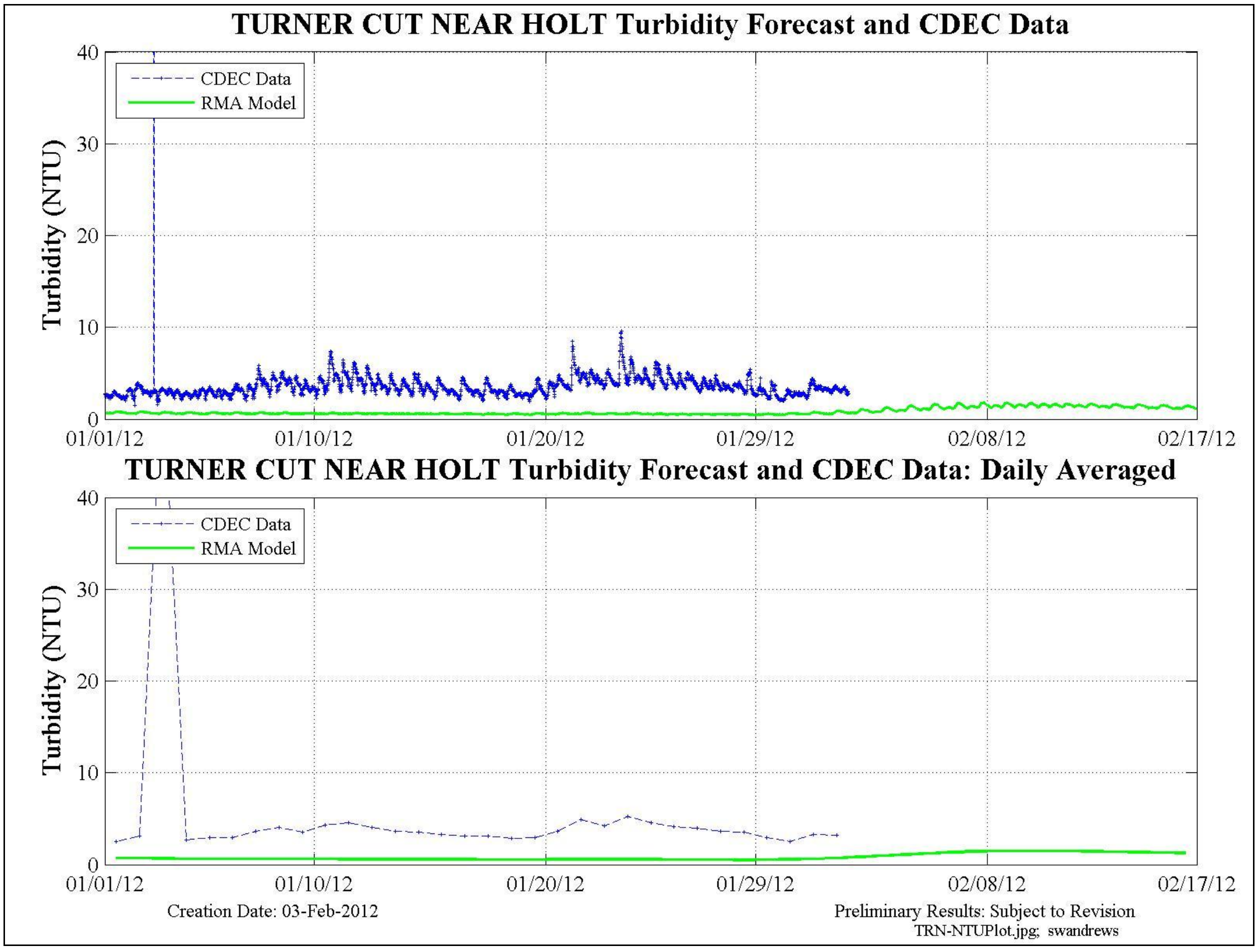

Figure 24 Model forecast and raw CDEC data at Turner Cut near Holt. Both 15-min (upper) and daily averaged (lower) plots are shown.

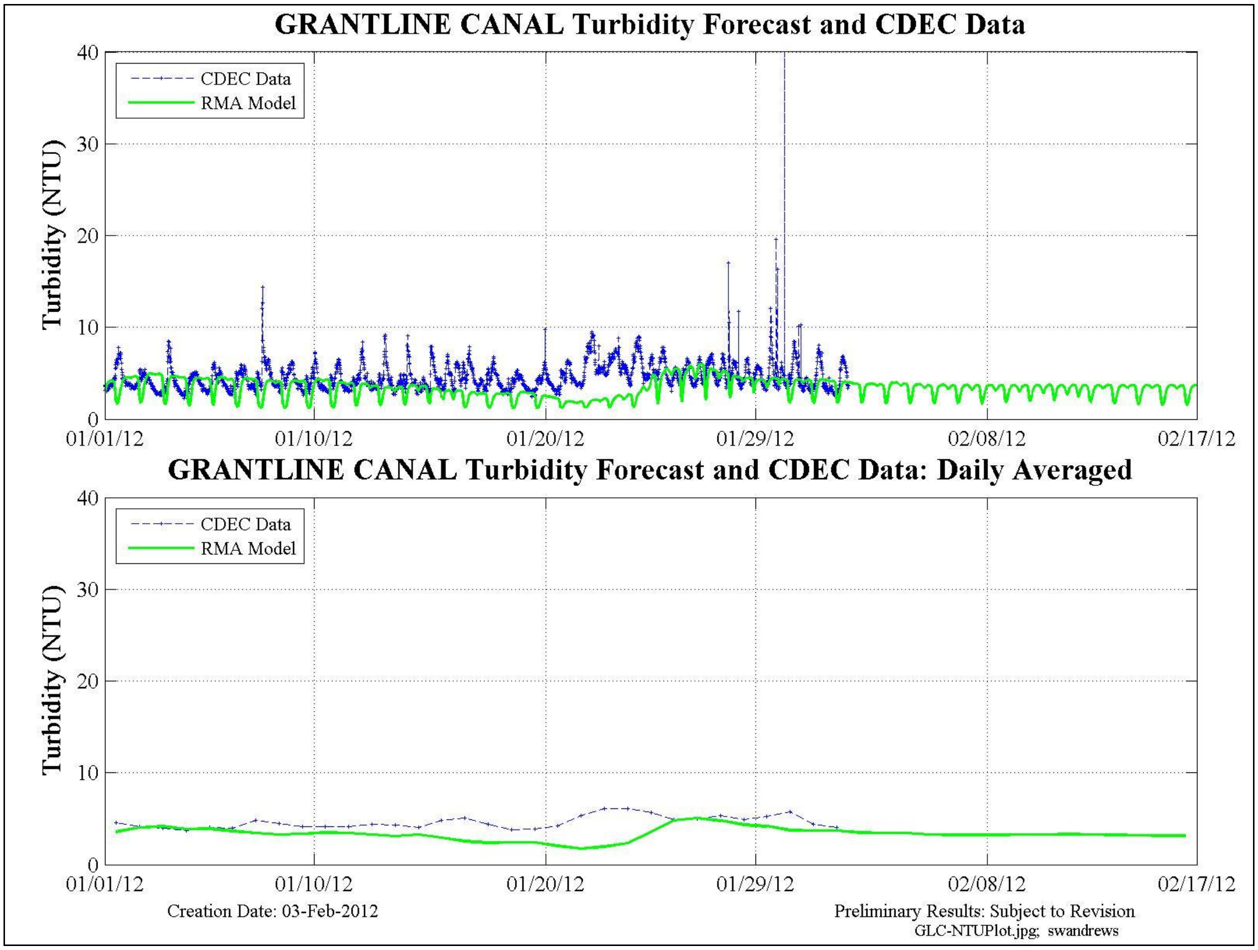

Figure 25 Model forecast and raw CDEC data at Grant Line. Both 15-min (upper) and daily averaged (lower) plots are shown.

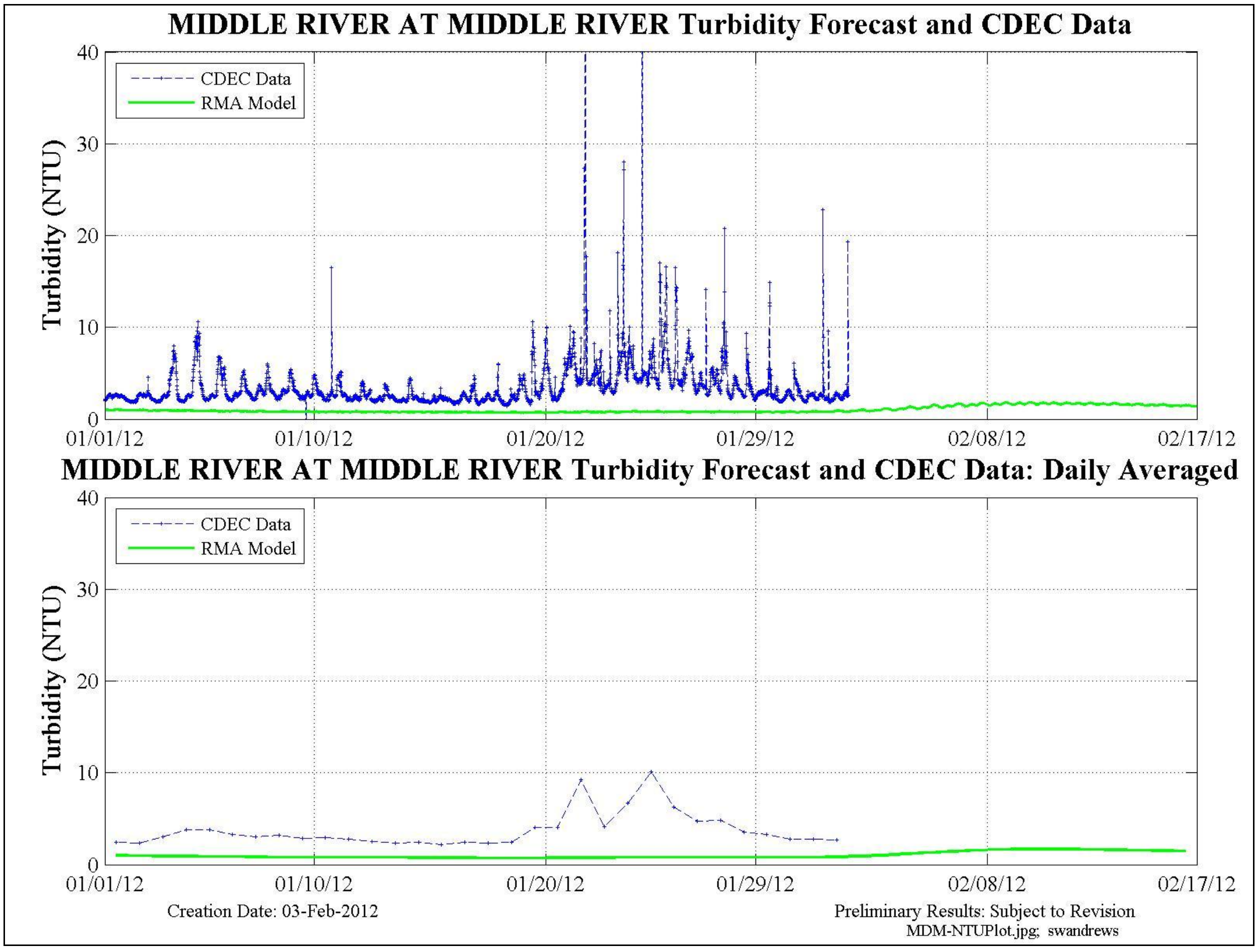

Figure 26 Model forecast and raw CDEC data at Middle R. at Middle R. Both 15-min (upper) and daily averaged (lower) plots are shown.

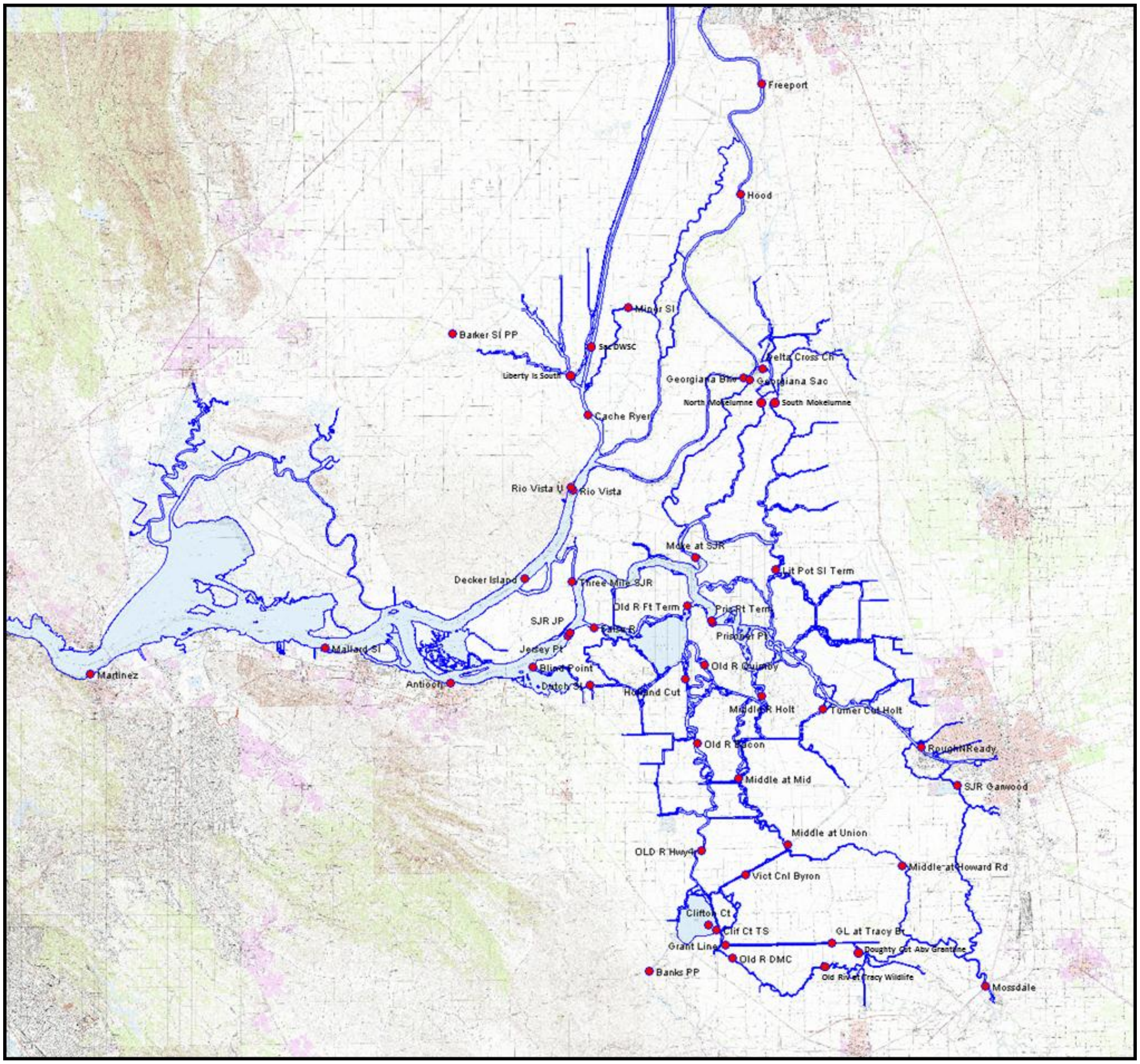

Figure 27 Figure illustrating model output and data collection locations.

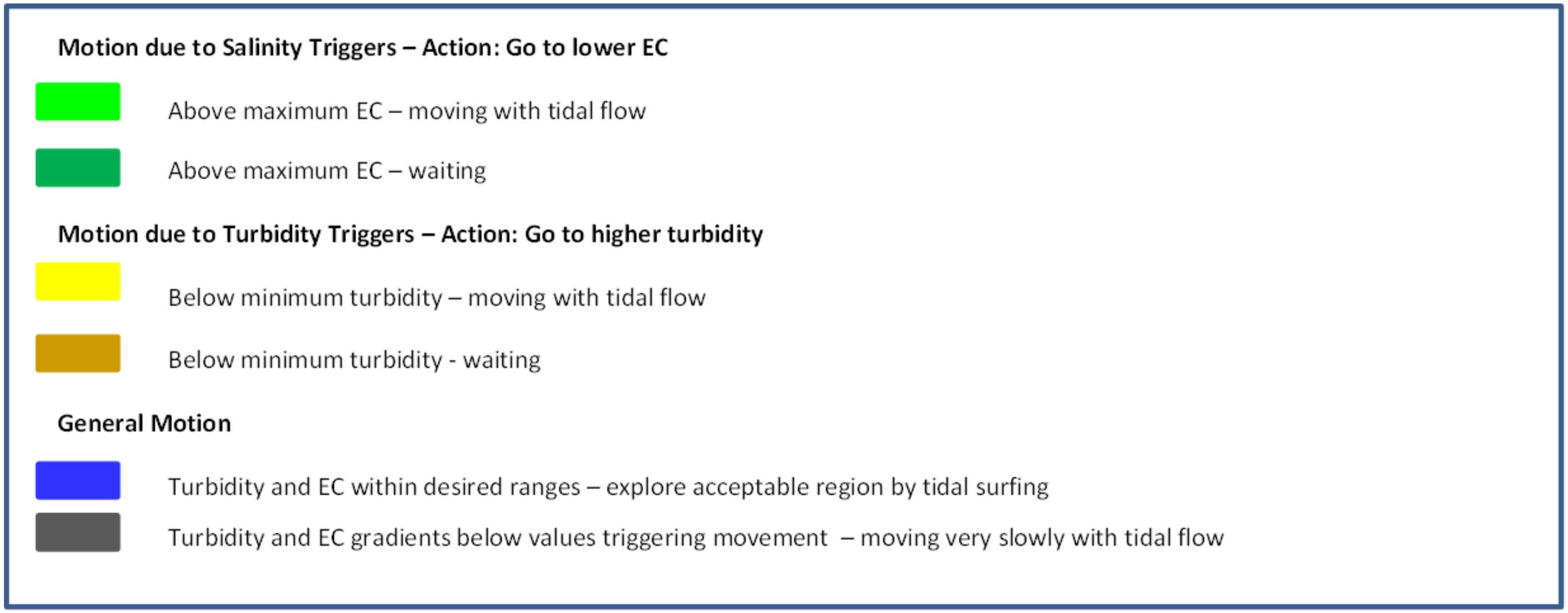

Figure 28 Particles in the Adult Delta Smelt particle tracking model are color-coded by the triggers influencing their behavior during the simulation. Use this figure to interpret the simplified color scale in the next three figures.

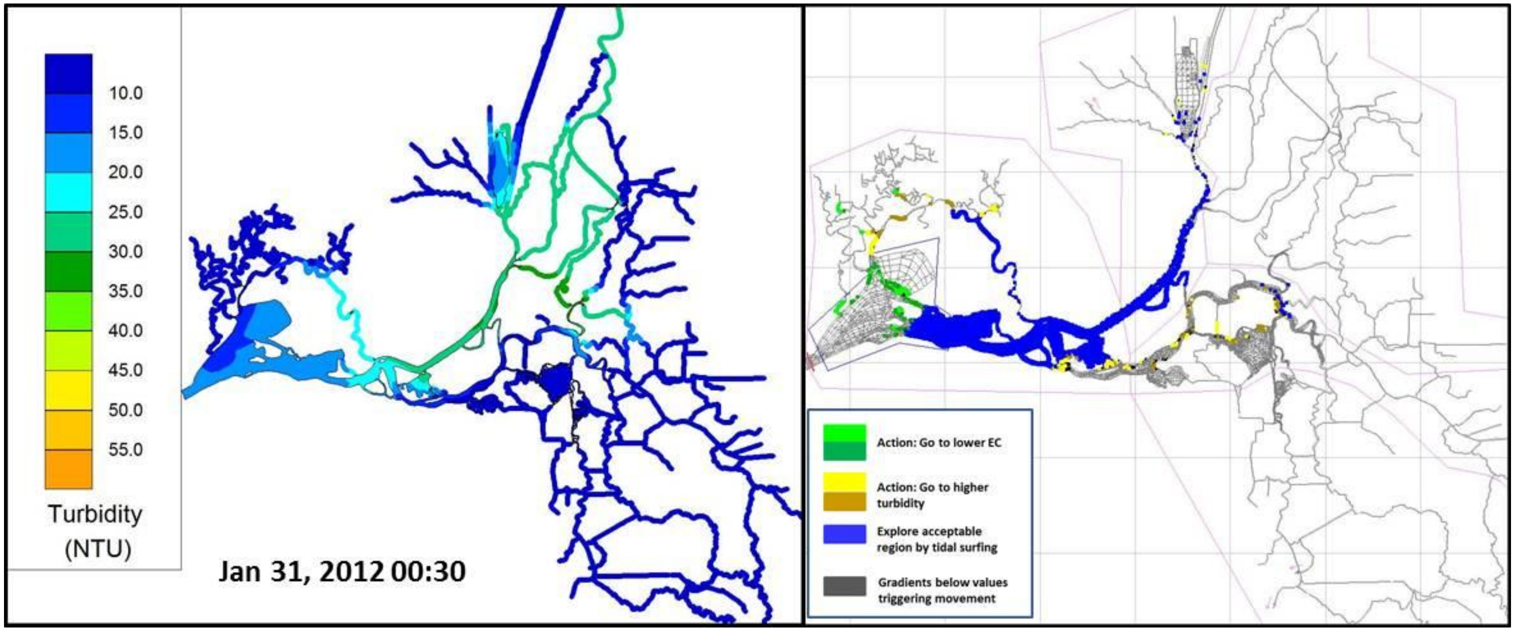

Figure 29 Turbidity contours and particle location in the RMA model grid on Jan. 31, 2012.

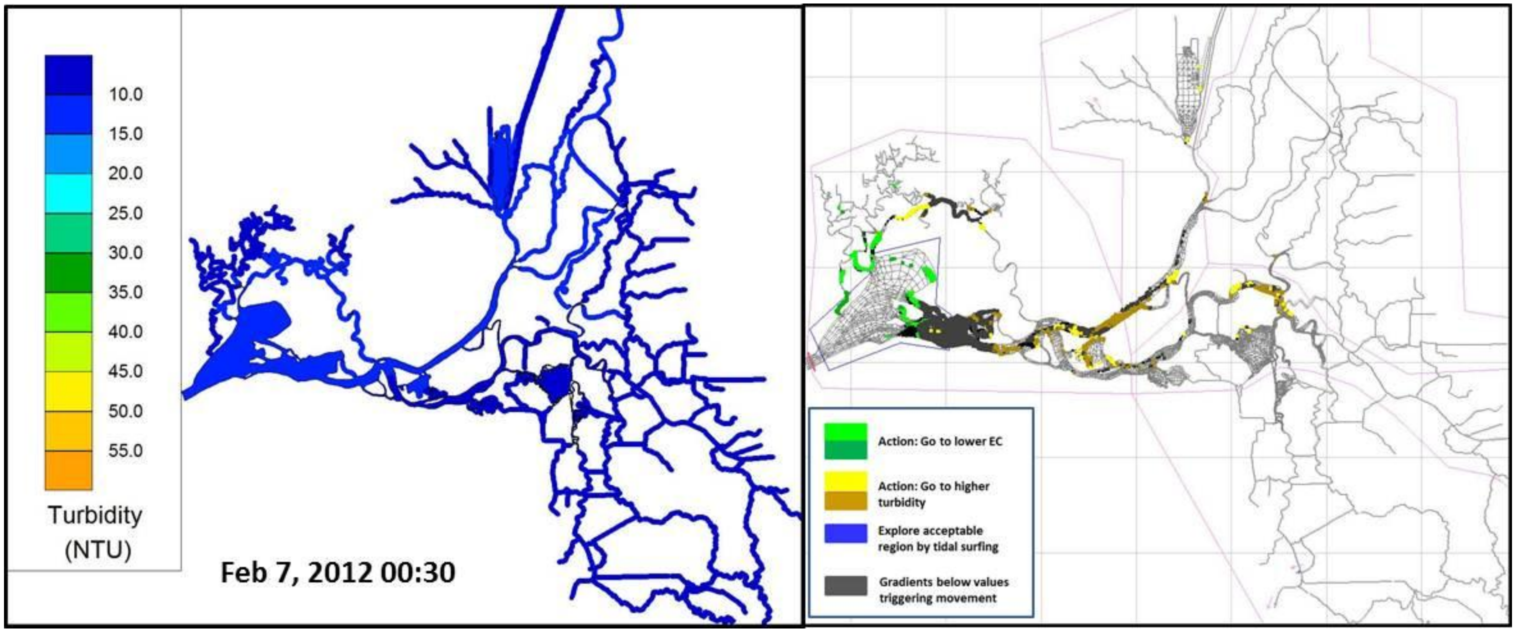

Figure 30 Turbidity contours and particle location in the RMA model grid on Feb. 7, 2012.

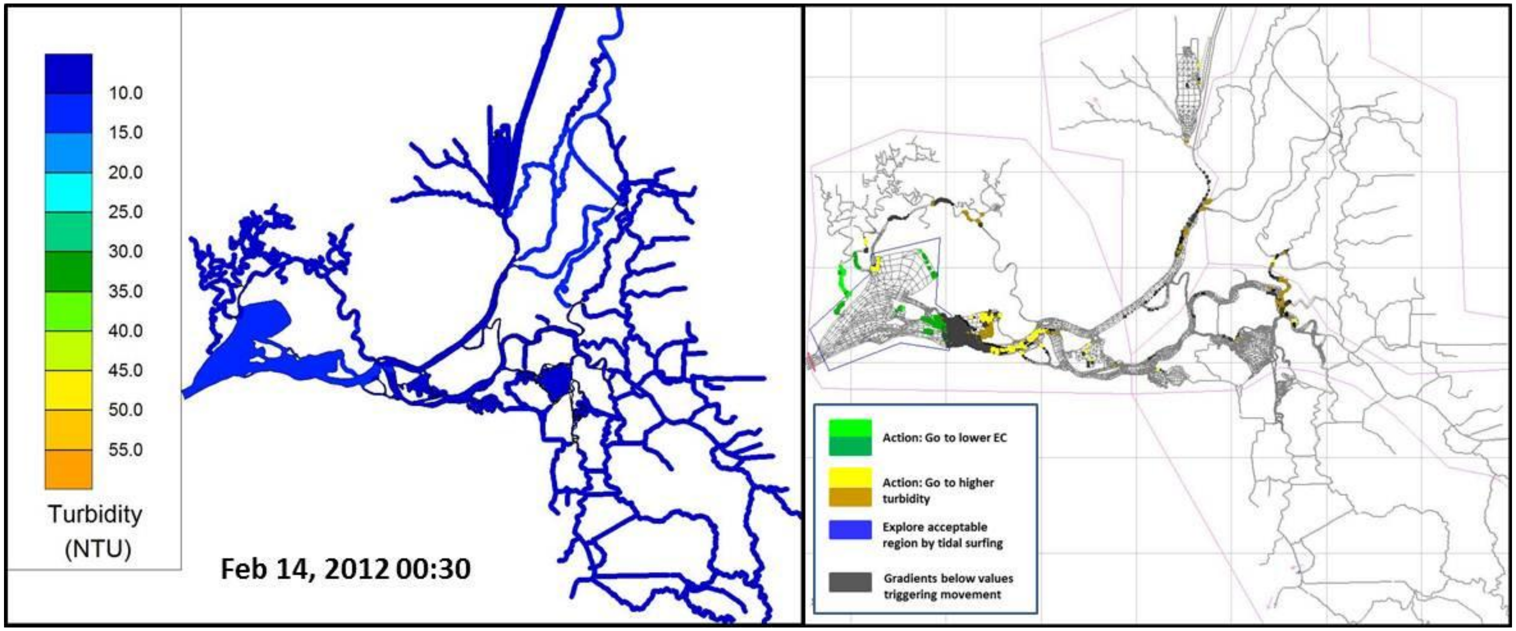

Figure 31 Turbidity contours and particle location in the RMA model grid on Feb. 14, 2012.

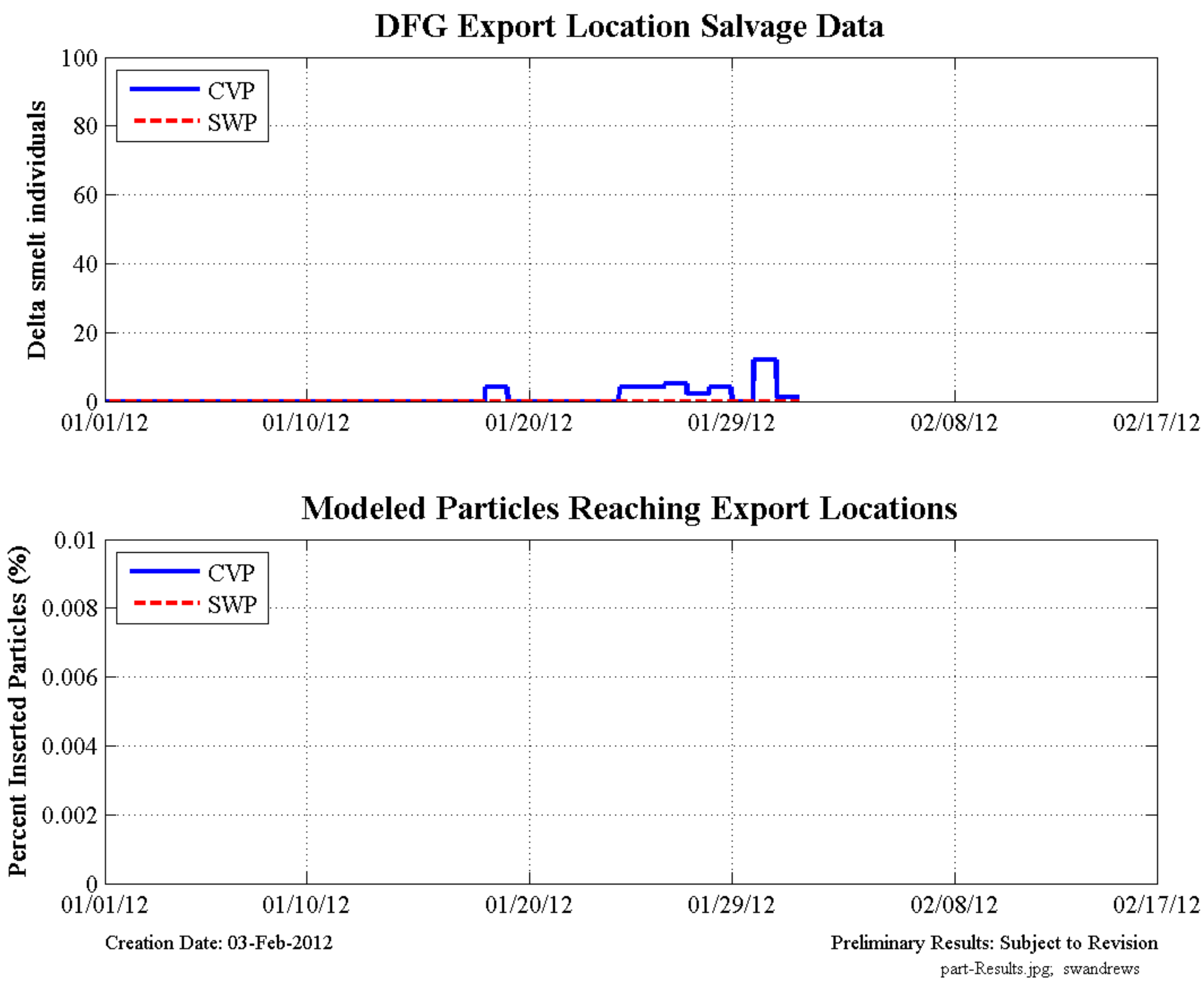

Figure 32 Comparison of DFG export location delta smelt salvage data (top) and RMA adult delta smelt particle tracking behavioral model results (bottom).